US009454143B2

(12) **United States Patent**
Raymond

(10) **Patent No.: US 9,454,143 B2**
(45) **Date of Patent: Sep. 27, 2016**

(54) **ELECTRICAL TRANSFER CAPACITY OPTIMIZATION SYSTEMS AND METHODS THEREOF**

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(72) Inventor: **Russell N. Raymond**, Tolland, CT (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 436 days.

(21) Appl. No.: **14/045,071**

(22) Filed: **Oct. 3, 2013**

(65) **Prior Publication Data**

US 2015/0100170 A1 Apr. 9, 2015

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/073,333, filed on Mar. 28, 2011, now abandoned.

(51) **Int. Cl.**
H02J 3/06 (2006.01)
G05B 19/042 (2006.01)

(52) **U.S. Cl.**
CPC ***G05B 19/042*** (2013.01); ***H02J 3/06*** (2013.01)

(58) **Field of Classification Search**
CPC G05B 19/042; H02J 3/06
USPC 700/286
See application file for complete search history.

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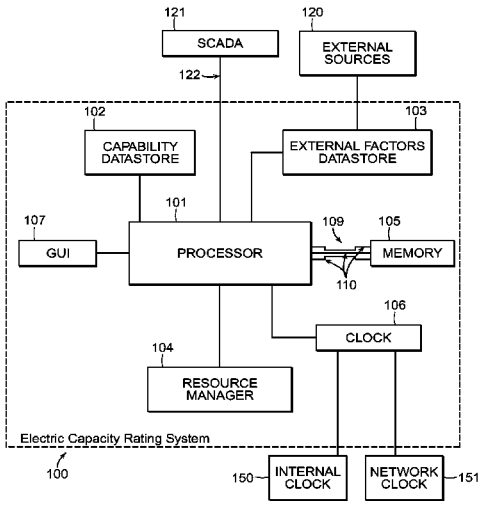
Primary Examiner — Mohammad Ali
Assistant Examiner — Yuhui R Pan
(74) *Attorney, Agent, or Firm* — UConn IP Clinic; Michael A. Blake; David M. Schwartz

(57) **ABSTRACT**

A method and system is provided for determining and optimizing electric transfer capacities of electric power system facilities. A processor receives and stores information that is used to compute the quantity of electric power that can flow through one or more electric power facilities. A capability datastore and an external factors datastore communicate with the processor and with each other. The capability datastore computes and stores the electrical transfer capability as a function time duration and at any given point in time while the external factors datastore determines a plurality of variables which affect the electrical transfer capabilities. A resource manager, connected to the processor, allocates resources by optimizing and correlating the electrical transfer capabilities with the plurality of variables, to generate an electrical transfer capacity rating for the one or more electric power facilities as a function of time duration and at any given point in time.

20 Claims, 17 Drawing Sheets



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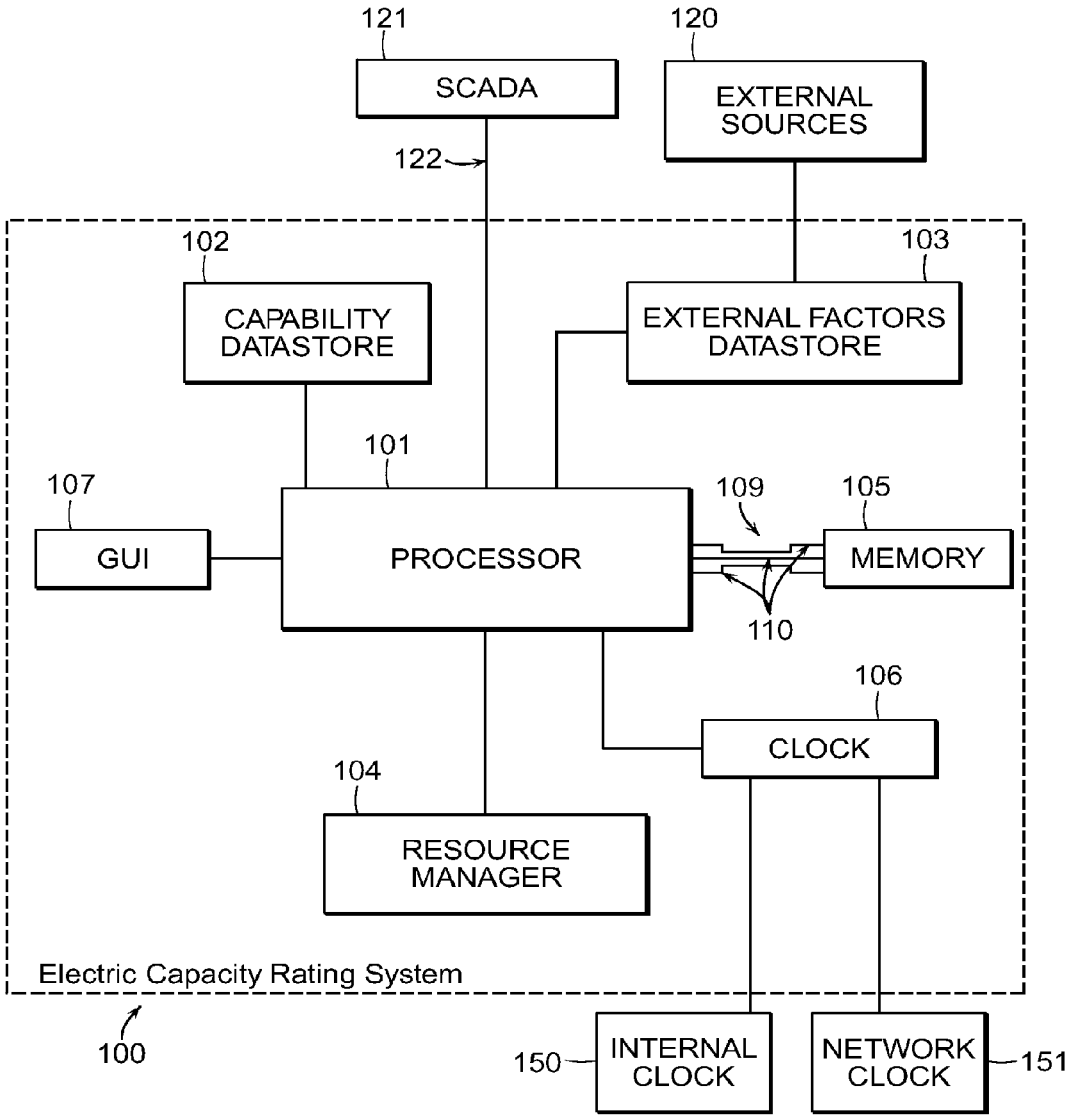
121
SCADA
120
EXTERNAL SOURCES
122
102
CAPABILITY DATASTORE
103
EXTERNAL FACTORS DATASTORE
101
107
GUI
PROCESSOR
109
105
MEMORY
110
106
CLOCK
104
RESOURCE MANAGER
Electric Capacity Rating System
100
150
INTERNAL CLOCK
NETWORK CLOCK
151

FIG. 1

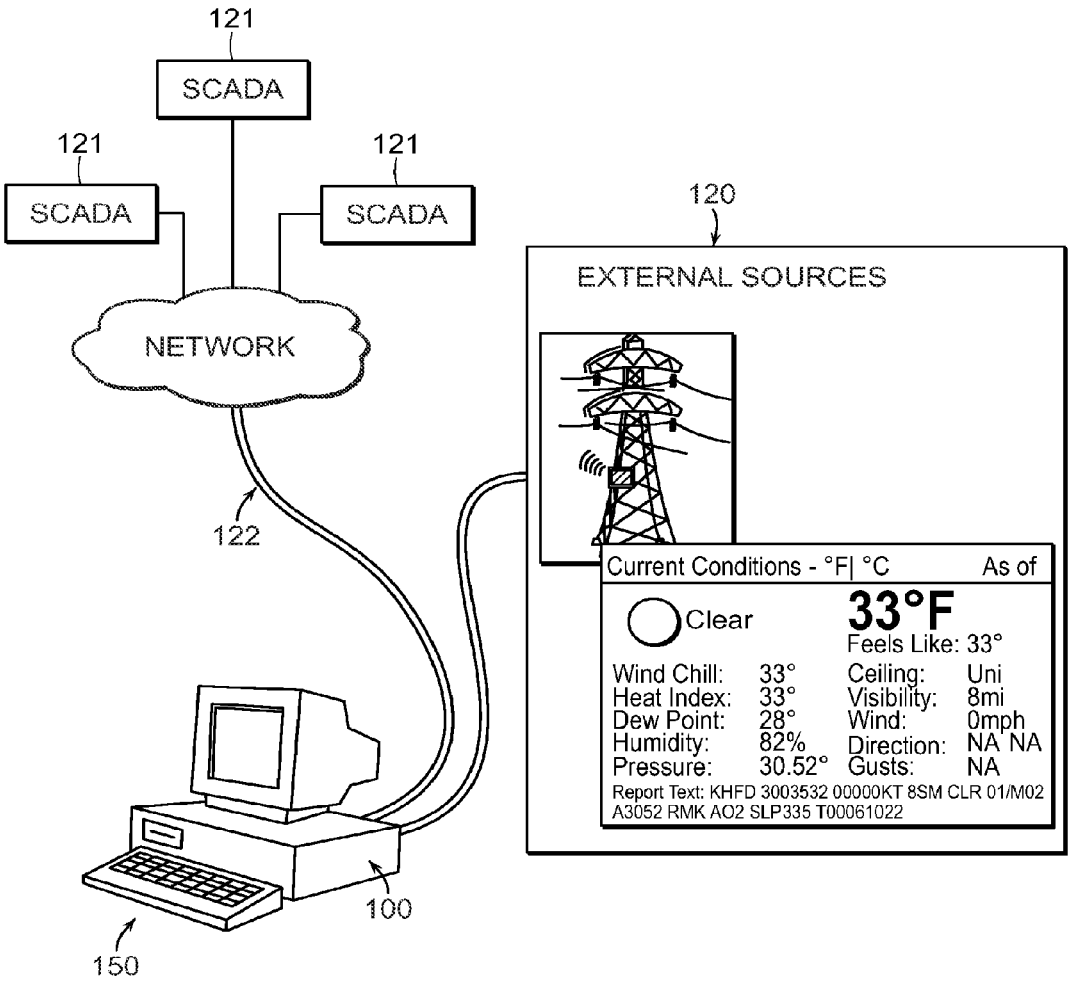
121
SCADA
121
SCADA
121
SCADA
120
EXTERNAL SOURCES
NETWORK
122
Current Conditions - °F| °C
As of
Clear
33°F
Feels Like: 33°
Wind Chill: 33°
Heat Index: 33°
Dew Point: 28°
Humidity: 82%
Pressure: 30.52°
Ceiling: Uni
Visibility: 8mi
Wind: 0mph
Direction: NA NA
Gusts: NA
Report Text: KHFD 3003532 00000KT 8SM CLR 01/M02 A3052 RMK AO2 SLP335 T00061022
100
150

FIG. 2

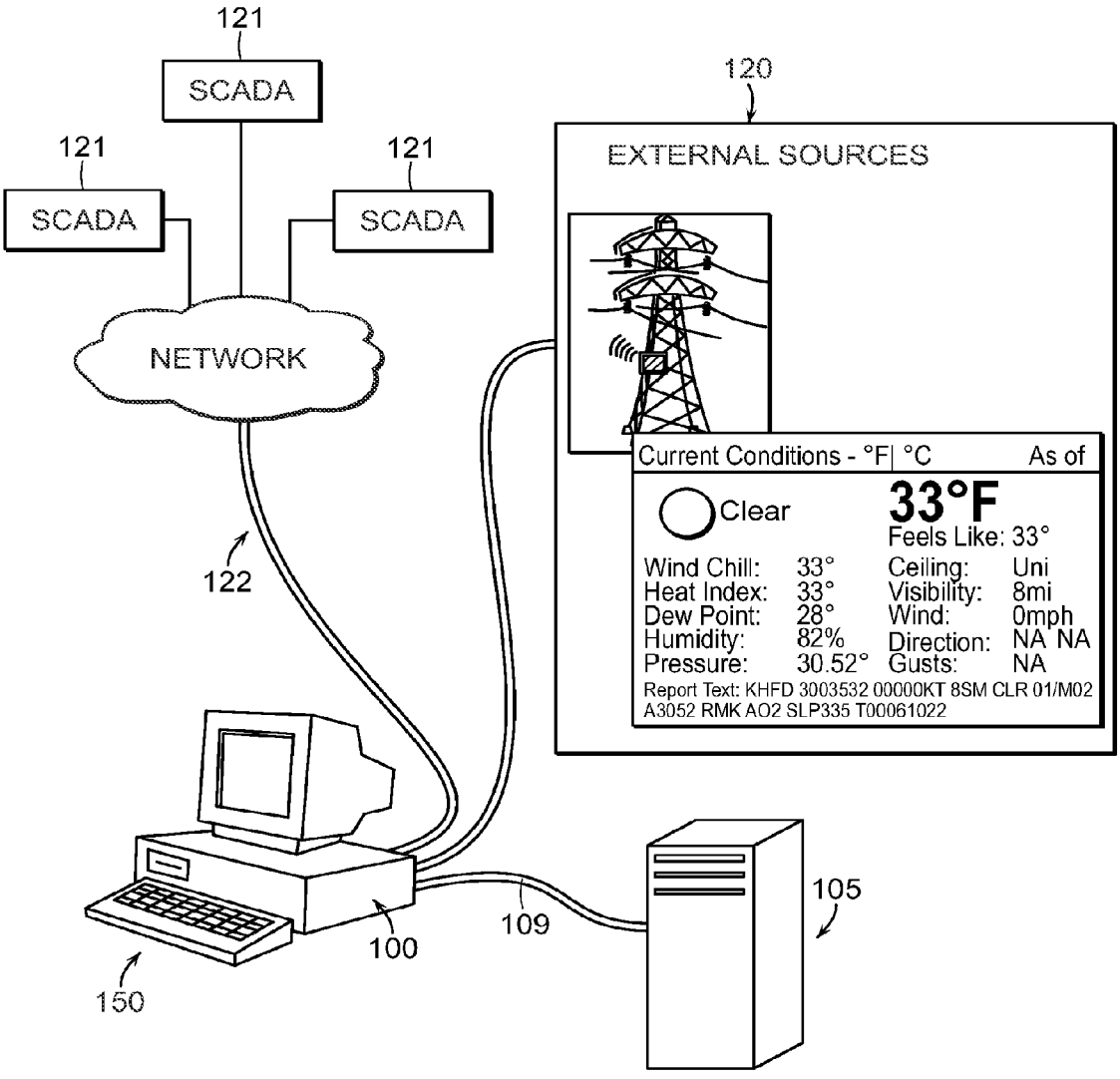
121
SCADA
121
SCADA
121
SCADA
NETWORK
122
120
EXTERNAL SOURCES
Current Conditions - °F| °C
As of
Clear
33°F
Feels Like: 33°
Wind Chill: 33°
Heat Index: 33°
Dew Point: 28°
Humidity: 82%
Pressure: 30.52°
Ceiling: Uni
Visibility: 8mi
Wind: 0mph
Direction: NA NA
Gusts: NA
Report Text: KHFD 3003532 00000KT 8SM CLR 01/M02 A3052 RMK AO2 SLP335 T00061022
105
109
100
150

FIG. 3

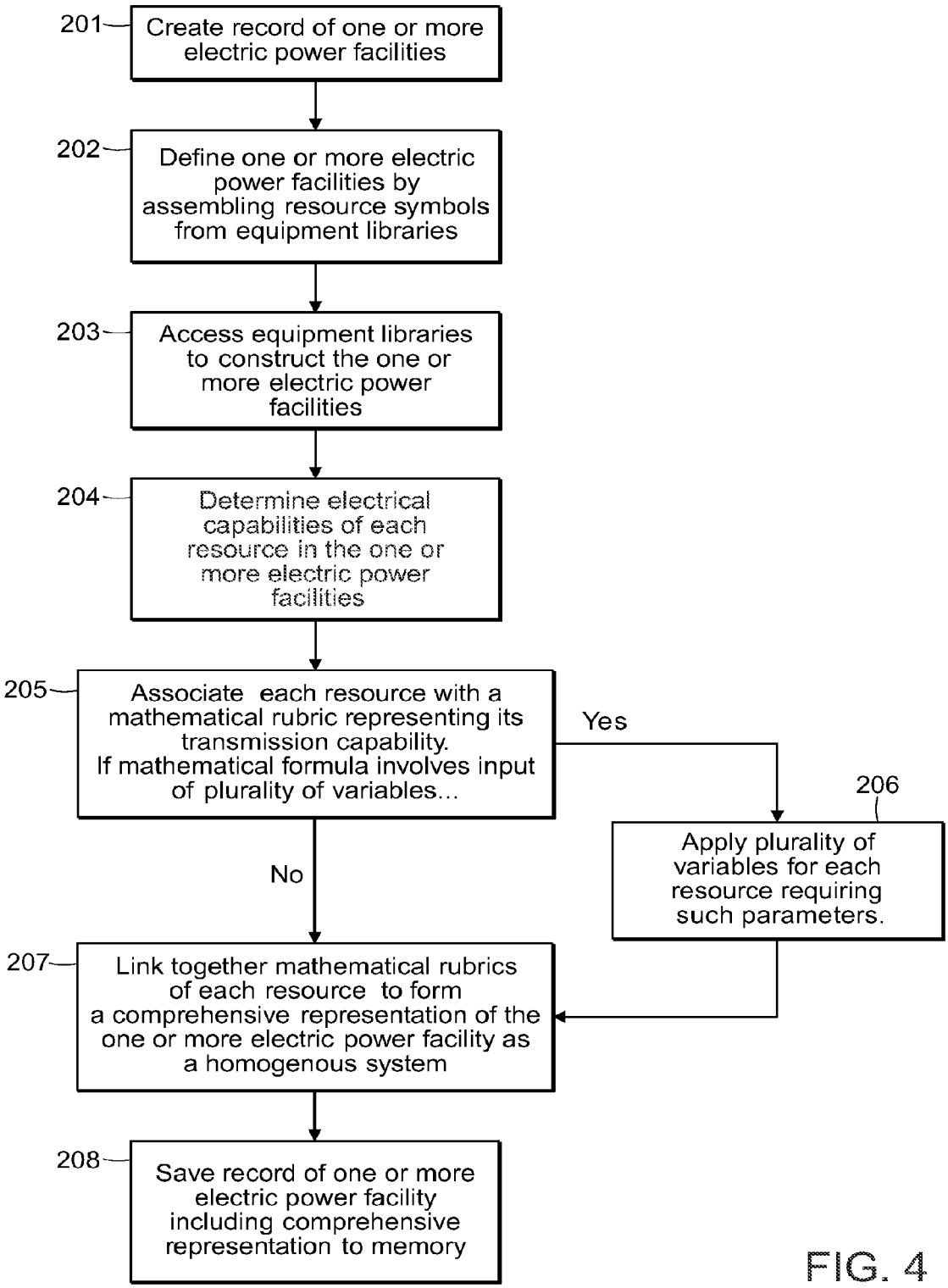
201
Create record of one or more electric power facilities
202
Define one or more electric power facilities by assembling resource symbols from equipment libraries
203
Access equipment libraries to construct the one or more electric power facilities
204
Determine electrical capabilities of each resource in the one or more electric power facilities
205
Associate each resource with a mathematical rubric representing its transmission capability. If mathematical formula involves input of plurality of variables...
Yes
206
Apply plurality of variables for each resource requiring such parameters.
No
207
Link together mathematical rubrics of each resource to form a comprehensive representation of the one or more electric power facility as a homogenous system
208
Save record of one or more electric power facility including comprehensive representation to memory

FIG. 4

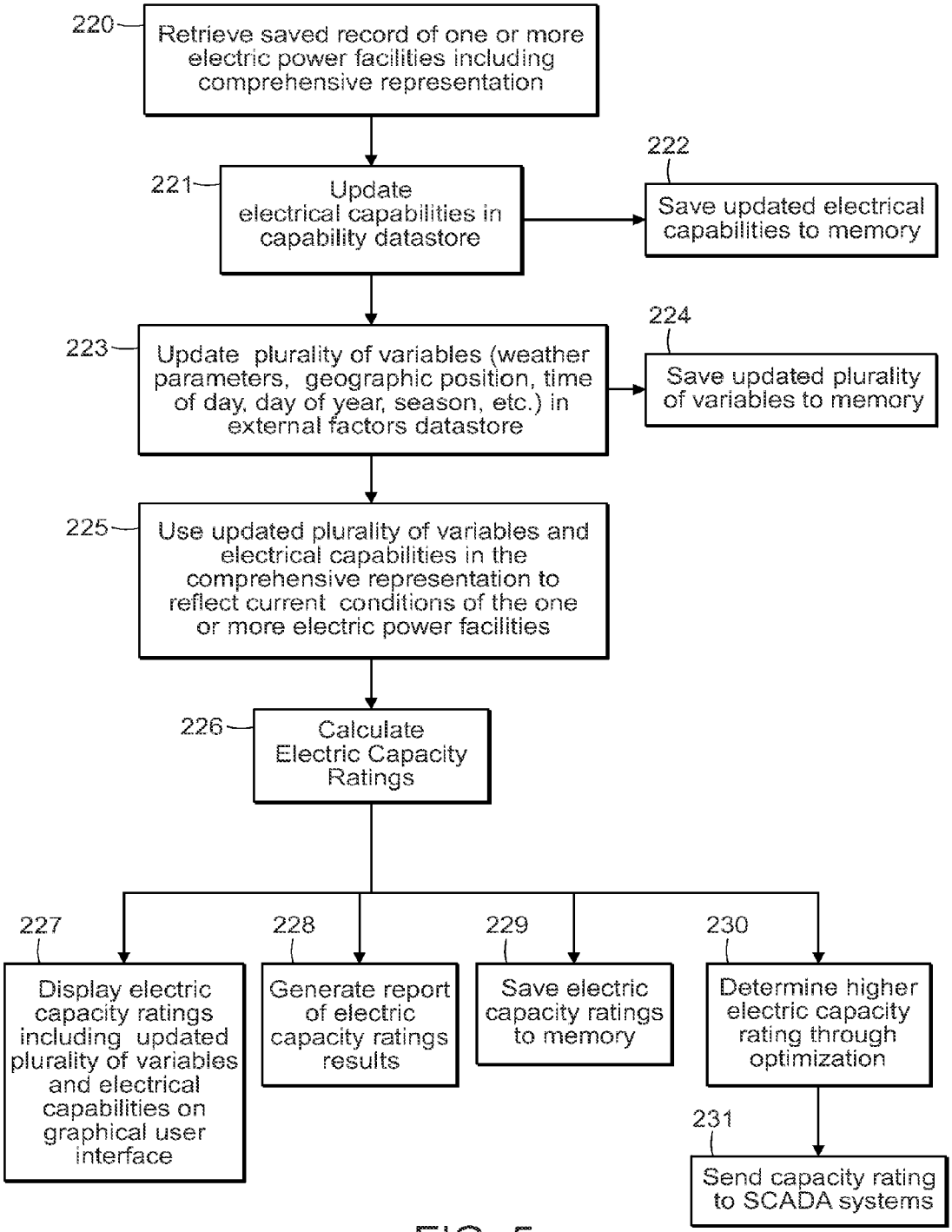
220
Retrieve saved record of one or more electric power facilities including comprehensive representation
221
Update electrical capabilities in capability datastore
222
Save updated electrical capabilities to memory
223
Update plurality of variables (weather parameters, geographic position, time of day, day of year, season, etc.) in external factors datastore
224
Save updated plurality of variables to memory
225
Use updated plurality of variables and electrical capabilities in the comprehensive representation to reflect current conditions of the one or more electric power facilities
226
Calculate Electric Capacity Ratings
227
Display electric capacity ratings including updated plurality of variables and electrical capabilities on graphical user interface
228
Generate report of electric capacity ratings results
229
Save electric capacity ratings to memory
230
Determine higher electric capacity rating through optimization
231
Send capacity rating to SCADA systems

FIG. 5

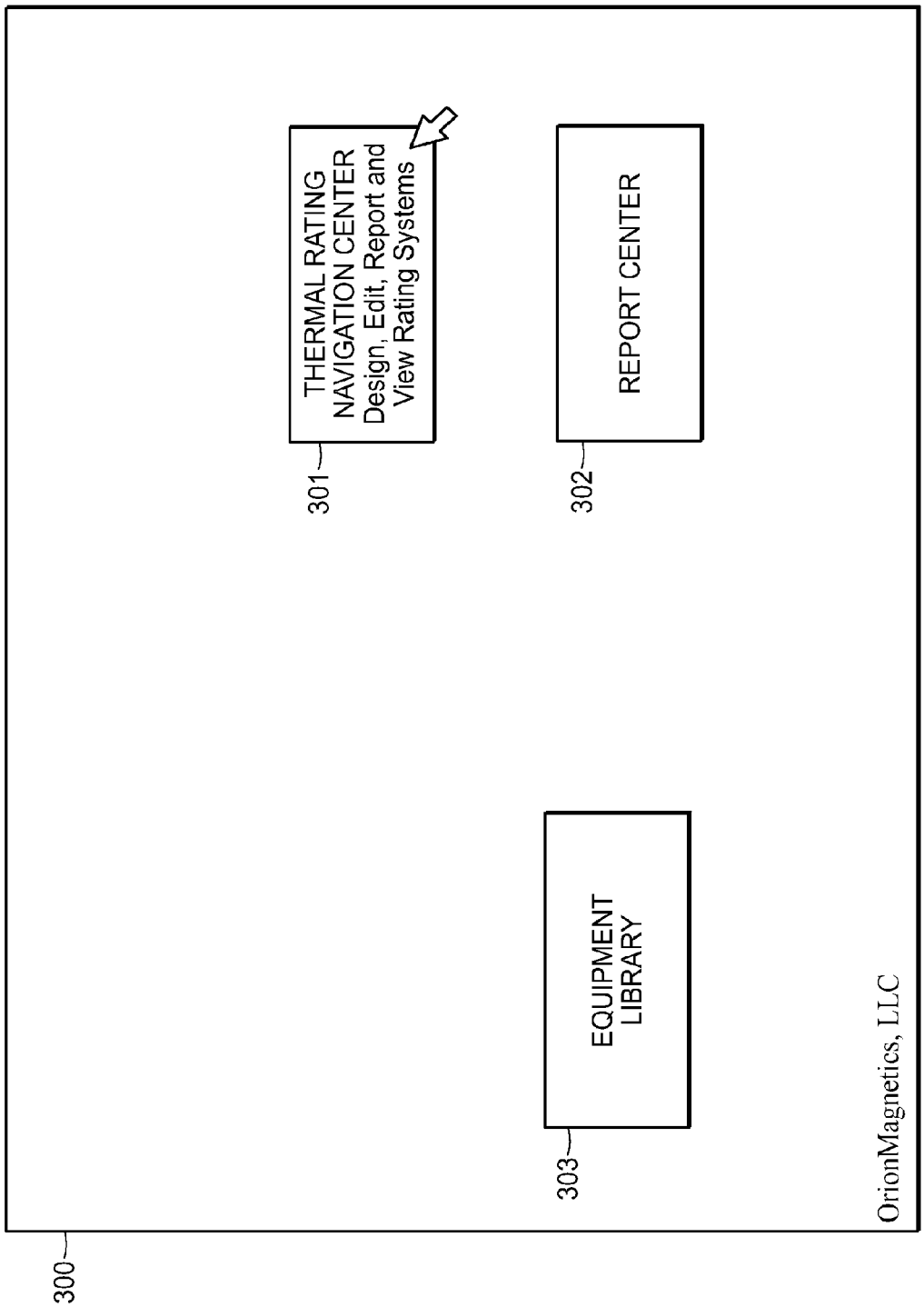
300
THERMAL RATING NAVIGATION CENTER Design, Edit, Report and View Rating Systems
301
REPORT CENTER
302
EQUIPMENT LIBRARY
303
OrionMagnetics, LLC

FIG. 6

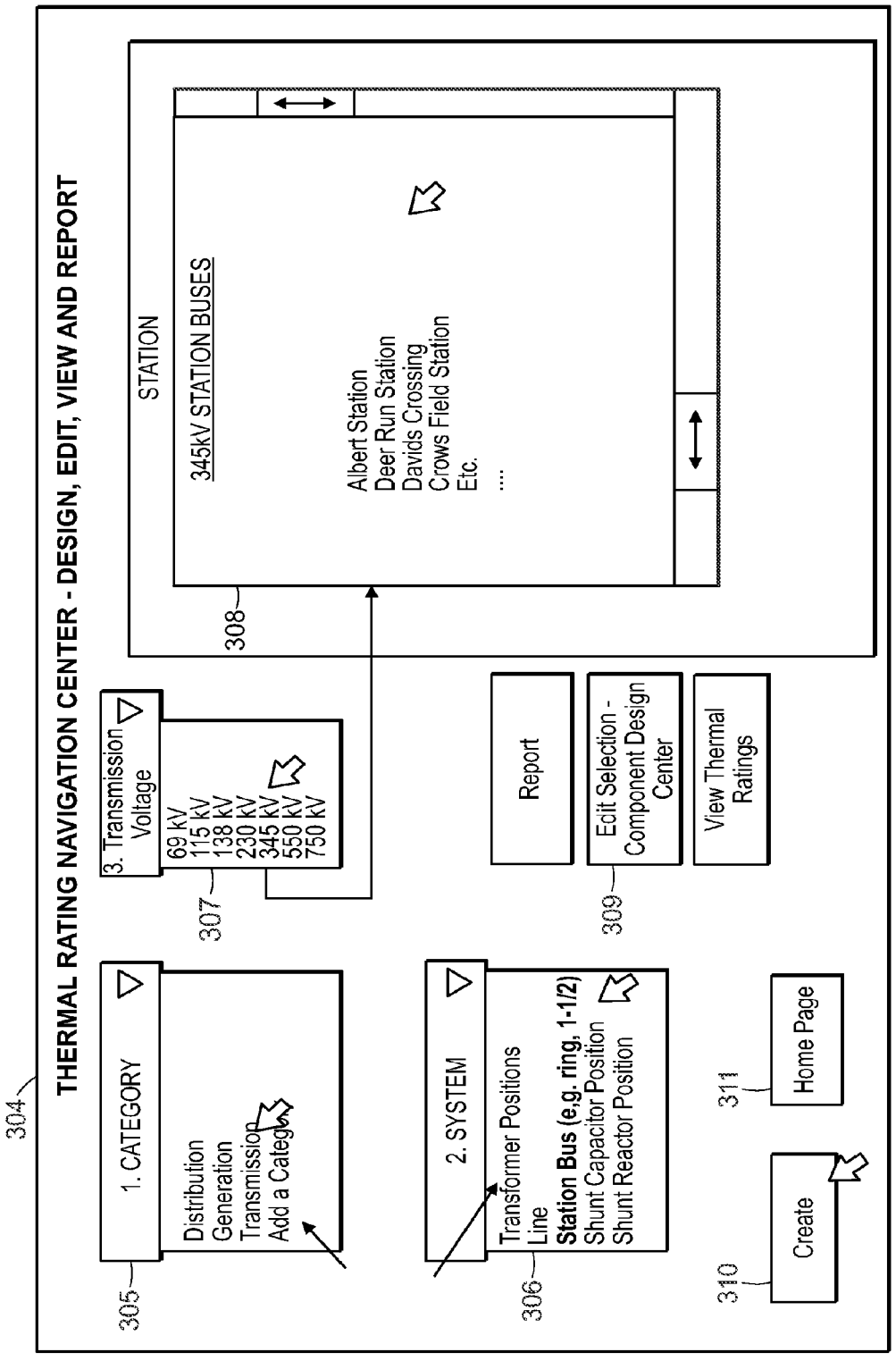
304
THERMAL RATING NAVIGATION CENTER - DESIGN, EDIT, VIEW AND REPORT
1. CATEGORY
Distribution
Generation
Transmission
Add a Category
305
2. SYSTEM
Transformer Positions
Line
Station Bus (e.g. ring, 1-1/2)
Shunt Capacitor Position
Shunt Reactor Position
306
3. Transmission Voltage
69 kV
115 kV
138 kV
230 kV
345 kV
550 kV
750 kV
307
STATION
345kV STATION BUSES
Albert Station
Deer Run Station
Davids Crossing
Crows Field Station
Etc.
....
308
Report
Edit Selection - Component Design Center
View Thermal Ratings
309
Create
310
Home Page
311

FIG. 7

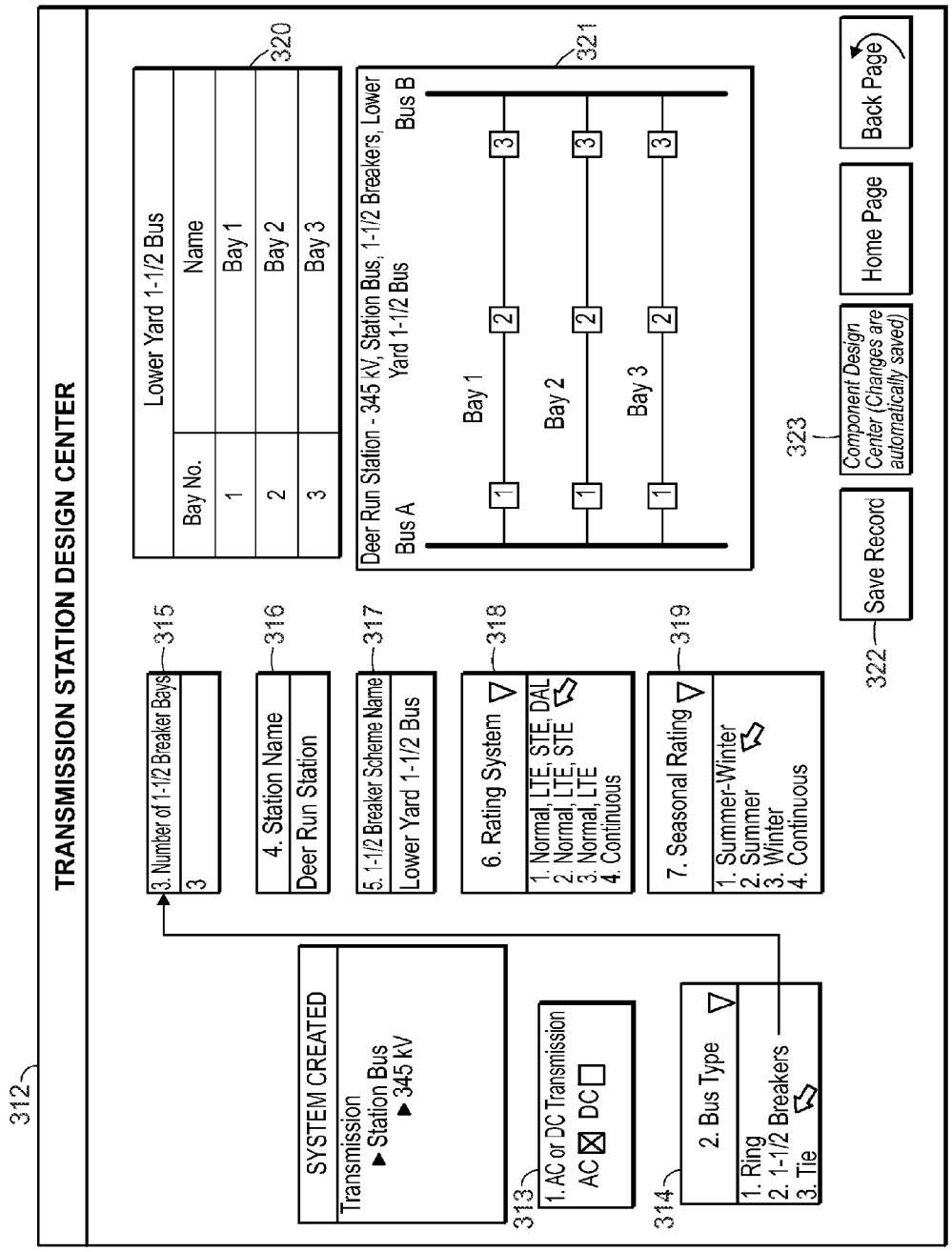
312
TRANSMISSION STATION DESIGN CENTER
SYSTEM CREATED
Transmission
▲ Station Bus
▲ 345 kV
313
1. AC or DC Transmission
AC ☒ DC ☐
314
2. Bus Type
1. Ring
2. 1-1/2 Breakers
3. Tie
3. Number of 1-1/2 Breaker Bays
3
315
4. Station Name
Deer Run Station
316
5. 1-1/2 Breaker Scheme Name
Lower Yard 1-1/2 Bus
317
6. Rating System
1. Normal, LTE, STE, DAL
2. Normal, LTE, STE
3. Normal, LTE
4. Continuous
318
7. Seasonal Rating
1. Summer-Winter
2. Summer
3. Winter
4. Continuous
319
Lower Yard 1-1/2 Bus
Bay No.
Name
1
Bay 1
2
Bay 2
3
Bay 3
320
Deer Run Station - 345 kV, Station Bus, 1-1/2 Breakers, Lower Yard 1-1/2 Bus
Bus A
Bus B
Bay 1
Bay 2
Bay 3
321
322
Save Record
323
Component Design Center (Changes are automatically saved)
Home Page
Back Page

FIG. 8

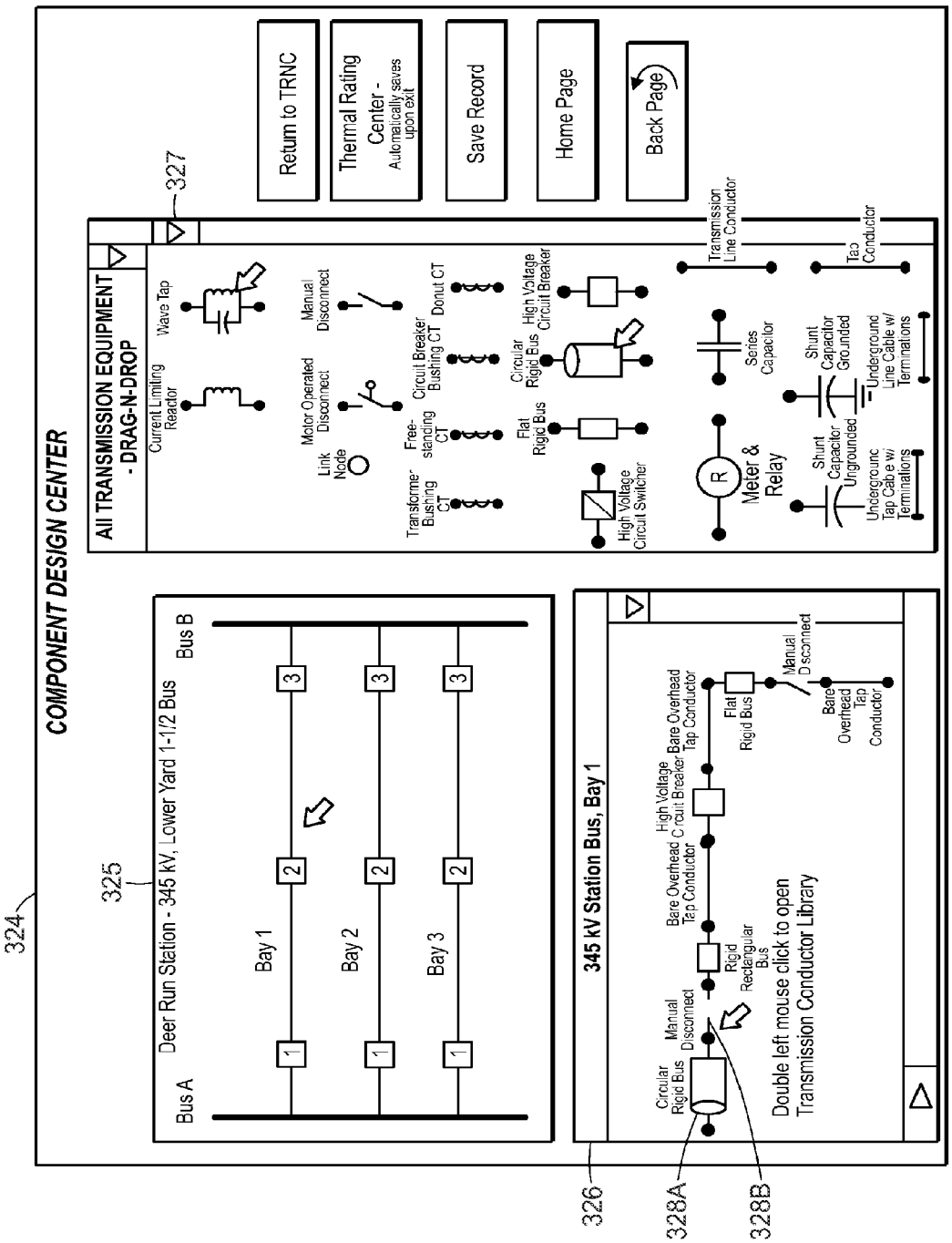
COMPONENT DESIGN CENTER
324
325
Deer Run Station - 345 kV, Lower Yard 1-1/2 Bus
Bus A
Bus B
Bay 1
Bay 2
Bay 3
1
2
3
All TRANSMISSION EQUIPMENT
- DRAG-N-DROP
327
Current Limiting Reactor
Wave Trap
Motor Operated Disconnect
Manual Disconnect
Link Node
Free-standing CT
Circuit Breaker Bushing CT
Donut CT
Transformer Bushing CT
Flat Rigid Bus
Circular Rigid Bus
High Voltage Circuit Breaker
High Voltage Circuit Switcher
Meter & Relay
Series Capacitor
Shunt Capacitor Ungrounded
Shunt Capacitor Grounded
Undergrounc Tap Cable w/ Terminations
Undergrounc Line Cable w/ Terminations
Transmission Line Conductor
Tap Conductor
Return to TRNC
Thermal Rating Center - Automatically saves upon exit
Save Record
Home Page
Back Page
345 kV Station Bus, Bay 1
Circular Rigid Bus
Manual Disconnect
Rigid Rectangular Bus
Bare Overhead Tap Conductor
High Voltage Circuit Breaker
Bare Overhead Tap Conductor
Flat Rigid Bus
Manual Disconnect
Bare Overhead Tap Conductor
Double left mouse click to open Transmission Conductor Library
326
328A
328B

FIG. 9

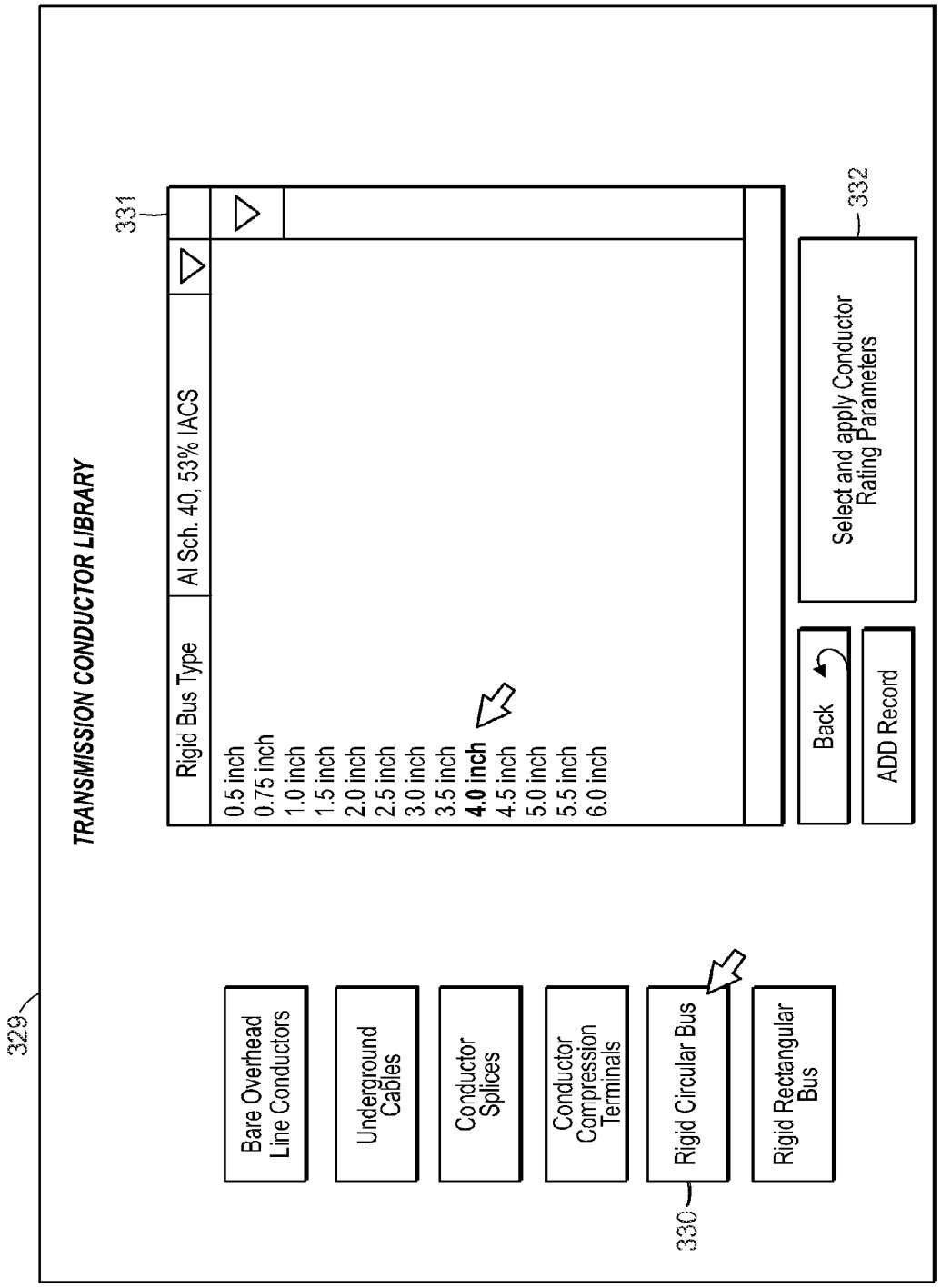
329
TRANSMISSION CONDUCTOR LIBRARY
331
Rigid Bus Type
Al Sch. 40, 53% IACS
0.5 inch
0.75 inch
1.0 inch
1.5 inch
2.0 inch
2.5 inch
3.0 inch
3.5 inch
4.0 inch
4.5 inch
5.0 inch
5.5 inch
6.0 inch
Back
ADD Record
Select and apply Conductor Rating Parameters
332
Bare Overhead Line Conductors
Underground Cables
Conductor Splices
Conductor Compression Terminals
Rigid Circular Bus
Rigid Rectangular Bus
330

FIG. 10

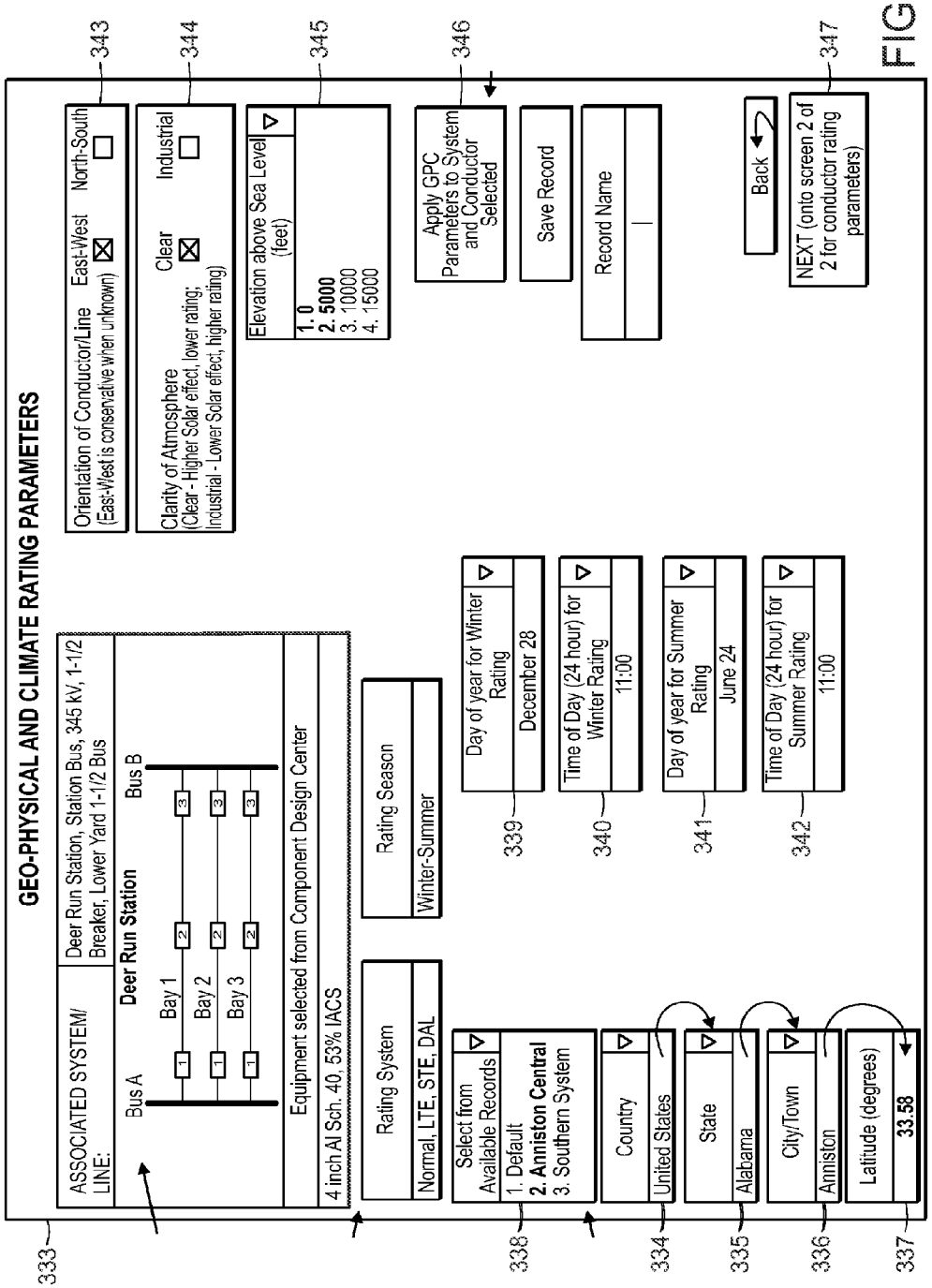
GEO-PHYSICAL AND CLIMATE RATING PARAMETERS
ASSOCIATED SYSTEM/ LINE:
Deer Run Station, Station Bus, 345 kV, 1-1/2 Breaker, Lower Yard 1-1/2 Bus
Bus A
Deer Run Station
Bus B
Bay 1
Bay 2
Bay 3
Equipment selected from Component Design Center
4 inch AI Sch. 40, 53% IACS
Rating System
Normal, LTE, STE, DAL
Rating Season
Winter-Summer
Select from Available Records
1. Default
2. Anniston Central
3. Southern System
Country
United States
State
Alabama
City/Town
Anniston
Latitude (degrees)
33.58
Day of year for Winter Rating
December 28
Time of Day (24 hour) for Winter Rating
11:00
Day of year for Summer Rating
June 24
Time of Day (24 hour) for Summer Rating
11:00
Orientation of Conductor/Line (East-West is conservative when unknown)
East-West
North-South
Clarity of Atmosphere (Clear - Higher Solar effect, lower rating; Industrial - Lower Solar effect, higher rating)
Clear
Industrial
Elevation above Sea Level (feet)
1. 0
2. 5000
3. 10000
4. 15000
Apply GPC Parameters to System and Conductor Selected
Save Record
Record Name
Back
NEXT (onto screen 2 of 2 for conductor rating parameters)
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347

FIG. 11

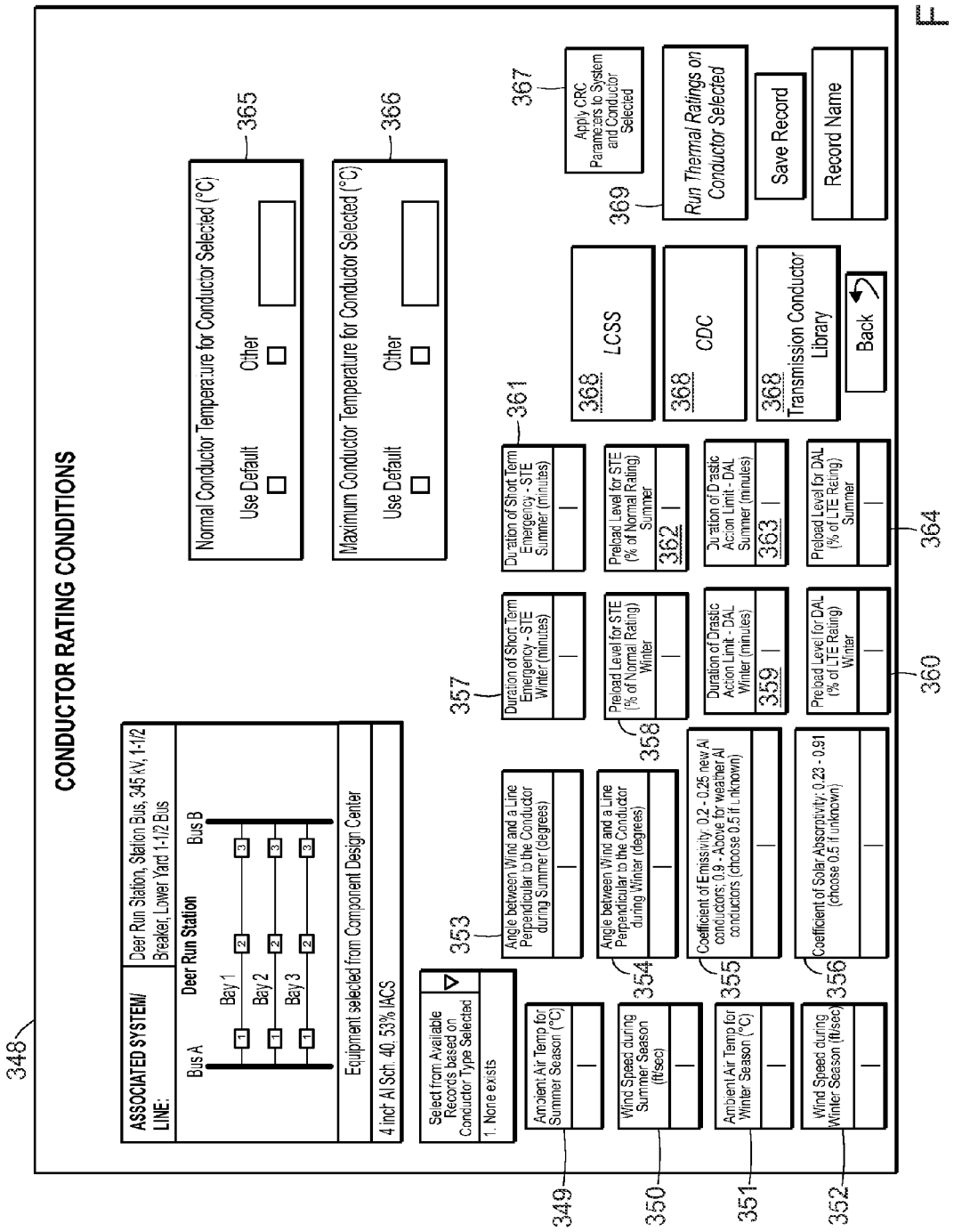
348
CONDUCTOR RATING CONDITIONS
ASSOCIATED SYSTEM/ LINE:
Deer Run Station, Station Bus, 345 kV, 1-1/2 Breaker, Lower Yard 1-1/2 Bus
Bus A
Deer Run Station
Bus B
Bay 1
Bay 2
Bay 3
Equipment selected from Component Design Center
4 incf Al Sch .40, 53% IACS
Select from Available Records based on Conductor Type Selected
1. None exists
353
Angle between Wind and a Line Perpendicular to the Conductor during Summer (degrees)
354
Angle between Wind and a Line Perpendicular to the Conductor during Winter (degrees)
355
Coefficient of Emissivity: 0.2 - 0.25 new Al conductors; 0.9 - Above for weather Al conductors (choose 0.5 if unknown)
356
Coefficient of Solar Absorptivity: 0.23 - 0.91 (choose 0.5 if unknown)
357
Duration of Short Term Emergency - STE Winter (minutes)
358
Preload Level for STE (% of Normal Rating) Winter
359
Duration of Drastic Action Limit - DAL Winter (minutes)
360
Preload Level for DAL (% of LTE Rating) Winter
361
Duration of Short Term Emergency - STE Summer (minutes)
362
Preload Level for STE (% of Normal Rating) Summer
363
Duration of Drastic Action Limit - DAL Summer (minutes)
364
Preload Level for DAL (% of LTE Rating) Summer
365
Normal Conductor Temperature for Conductor Selected (°C)
Use Default
Other
366
Maximum Conductor Temperature for Conductor Selected (°C)
Use Default
Other
367
Apply CRC Parameters to System and Conductor Selected
368
LCSS
368
CDC
368
Transmission Conductor Library
369
Run Thermal Ratings on Conductor Selected
Save Record
Record Name
Back
349
Ambient Air Temp for Summer Season (°C)
350
Wind Speed during Summer Season (ft/sec)
351
Ambient Air Temp for Winter Season (°C)
352
Wind Speed during Winter Season (ft/sec)

FIG. 12

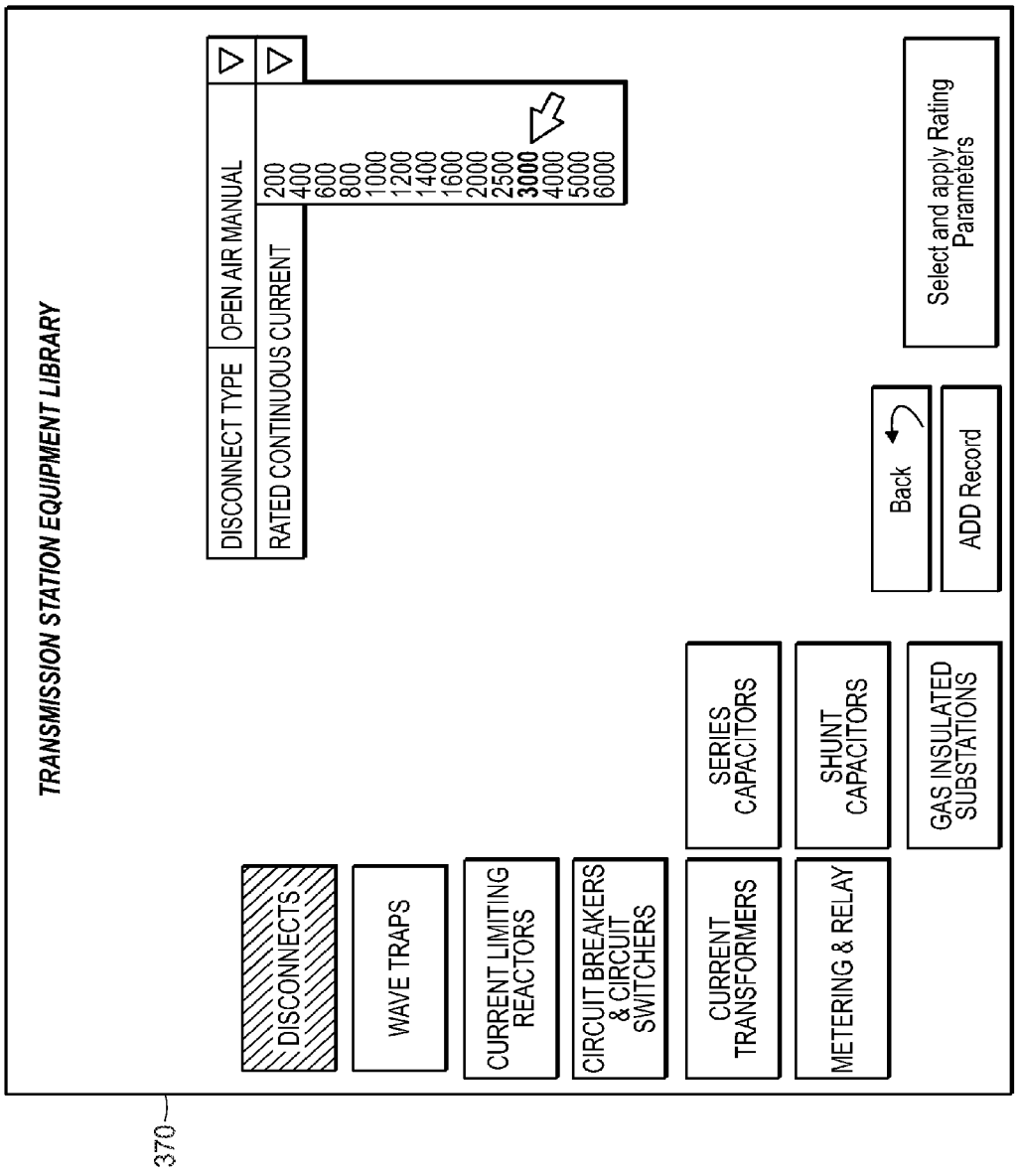
TRANSMISSION STATION EQUIPMENT LIBRARY
DISCONNECTS
WAVE TRAPS
CURRENT LIMITING REACTORS
CIRCUIT BREAKERS & CIRCUIT SWITCHERS
CURRENT TRANSFORMERS
METERING & RELAY
SERIES CAPACITORS
SHUNT CAPACITORS
GAS INSULATED SUBSTATIONS
DISCONNECT TYPE
OPEN AIR MANUAL
RATED CONTINUOUS CURRENT
200
400
600
800
1000
1200
1400
1600
2000
2500
3000
4000
5000
6000
Back
ADD Record
Select and apply Rating Parameters
370

FIG. 13

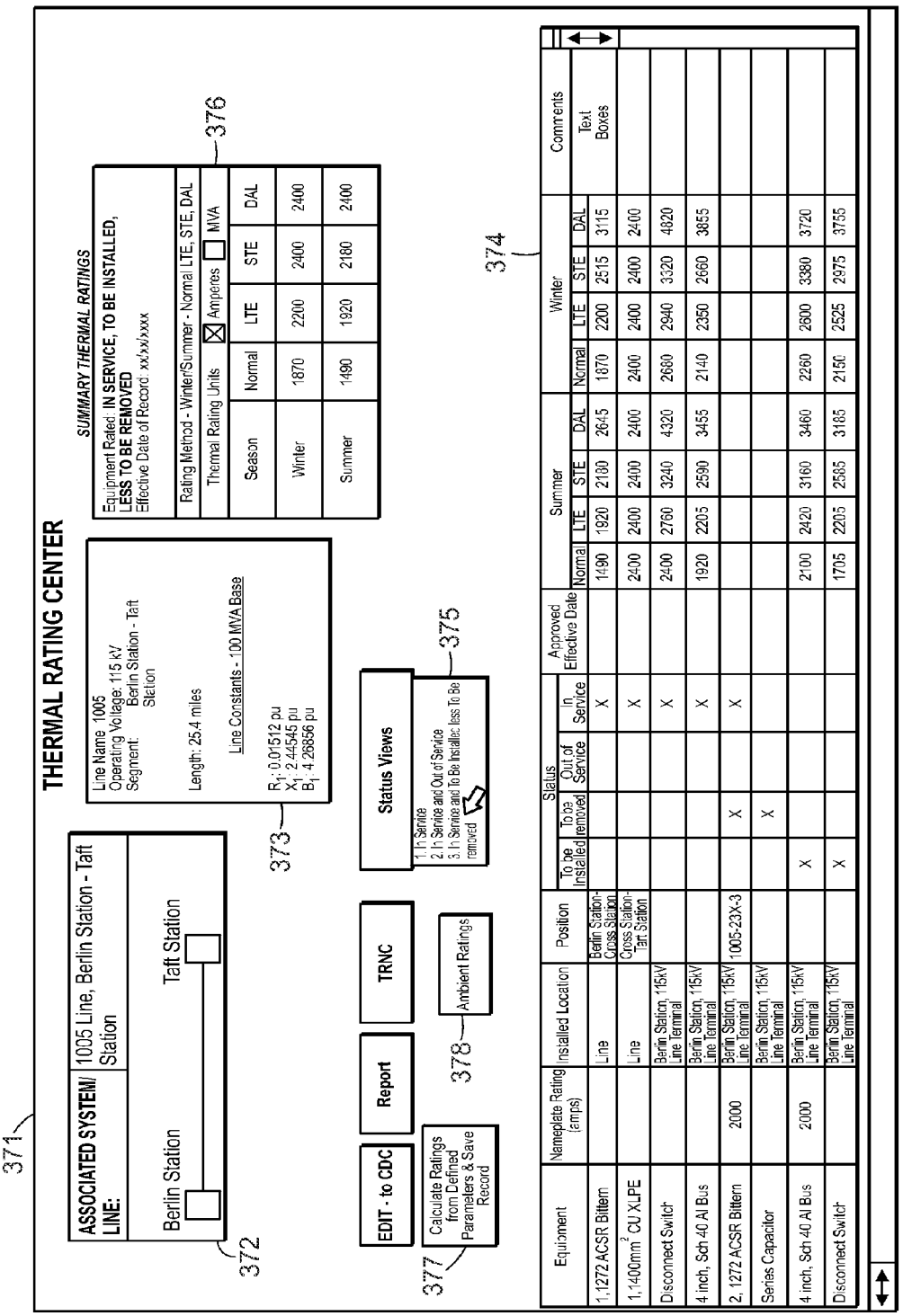
371
THERMAL RATING CENTER
ASSOCIATED SYSTEM/ LINE:
1005 Line, Berlin Station - Taft Station
Berlin Station
Taft Station
372
Line Name: 1005
Operating Voltage: 115 kV
Segment: Berlin Station - Taft Station
Length: 25.4 miles
Line Constants - 100 MVA Base
R1: 0.01512 pu
X1: 2.44545 pu
B1: 4.26856 pu
373
SUMMARY THERMAL RATINGS
Equipment Rated: IN SERVICE, TO BE INSTALLED, LESS TO BE REMOVED
Effective Date of Record: xx/xx/xxxx
Rating Method - Winter/Summer - Normal LTE, STE, DAL
Thermal Rating Units: Amperes MVA
376
Season | Normal | LTE | STE | DAL
Winter | 1870 | 2200 | 2400 | 2400
Summer | 1490 | 1920 | 2180 | 2400
EDIT - to CDC
Report
TRNC
Status Views
1. In Service
2. In Service and Out of Service
3. In Service and To Be Installed less To Be removed
375
377
Calculate Ratings from Defined Parameters & Save Record
378
Ambient Ratings
374
Equipment | Nameplate Rating (amps) | Installed Location | Position | Status: To be Installed | To be removed | Out of Service | In Service | Approved Effective Date | Summer: Normal | LTE | STE | DAL | Winter: Normal | LTE | STE | DAL | Comments: Text Boxes
1,1272 ACSR Bittern | | Line | Berlin Station-Cross Station | | | | X | | 1490 | 1920 | 2180 | 2645 | 1870 | 2200 | 2515 | 3115
1,1400mm² CU XLPE | | Line | Cross Station-Taft Station | | | | X | | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400
Disconnect Switch | | Berlin Station, 115kV Line Terminal | | | | | X | | 2400 | 2760 | 3240 | 4320 | 2660 | 2940 | 3320 | 4820
4 inch, Sch 40 Al Bus | | Berlin Station, 115kV Line Terminal | | | | | X | | 1920 | 2205 | 2590 | 3455 | 2140 | 2350 | 2660 | 3855
2, 1272 ACSR Bittern | 2000 | Berlin Station, 115kV Line Terminal | 1005-23X-3 | | X | | X | | | | | | | | | |
Series Capacitor | | Berlin Station, 115kV Line Terminal | | | X | | | | | | | | | | | |
4 inch, Sch 40 Al Bus | 2000 | Berlin Station, 115kV Line Terminal | | X | | | | | 2100 | 2420 | 3160 | 3460 | 2260 | 2600 | 3380 | 3720
Disconnect Switch | | Berlin Station, 115kV Line Terminal | | X | | | | | 1705 | 2205 | 2585 | 3185 | 2150 | 2525 | 2975 | 3755

FIG. 14

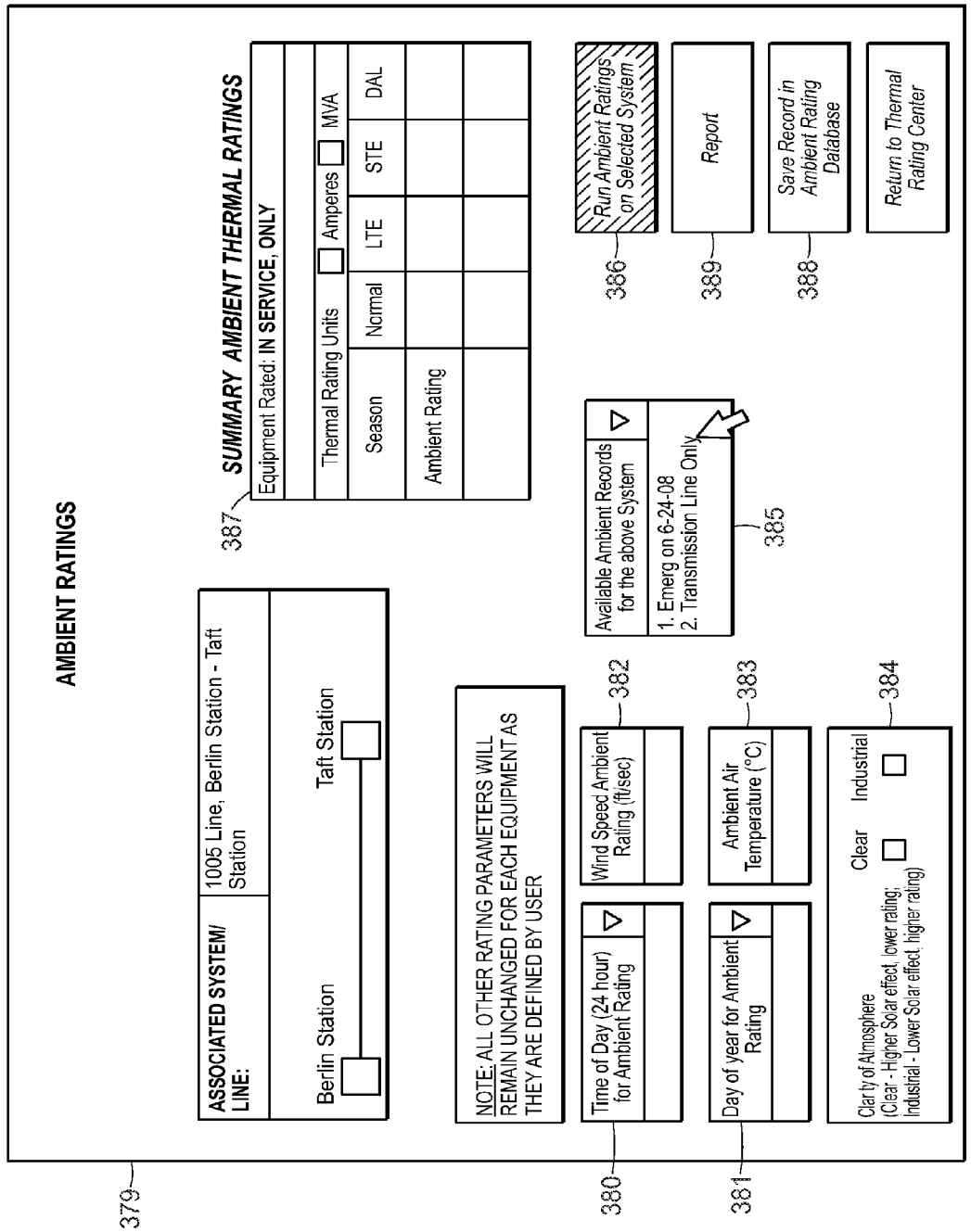
AMBIENT RATINGS
379
ASSOCIATED SYSTEM/ LINE:
1005 Line, Berlin Station - Taft Station
Berlin Station
Taft Station
NOTE: ALL OTHER RATING PARAMETERS WILL REMAIN UNCHANGED FOR EACH EQUIPMENT AS THEY ARE DEFINED BY USER
Time of Day (24 hour) for Ambient Rating
380
Day of year for Ambient Rating
381
Clarity of Atmosphere (Clear - Higher Solar effect, lower rating; Industrial - Lower Solar effect, higher rating)
Clear
Industrial
Wind Speed Ambient Rating (ft/sec)
382
Ambient Air Temperature (°C)
383
384
SUMMARY AMBIENT THERMAL RATINGS
387
Equipment Rated: IN SERVICE, ONLY
Thermal Rating Units
Amperes
MVA
Season
Normal
LTE
STE
DAL
Ambient Rating
Available Ambient Records for the above System
1. Emerg on 6-24-08
2. Transmission Line Only
385
Run Ambient Ratings on Selected System
386
Report
389
Save Record in Ambient Rating Database
388
Return to Thermal Rating Center

FIG. 15

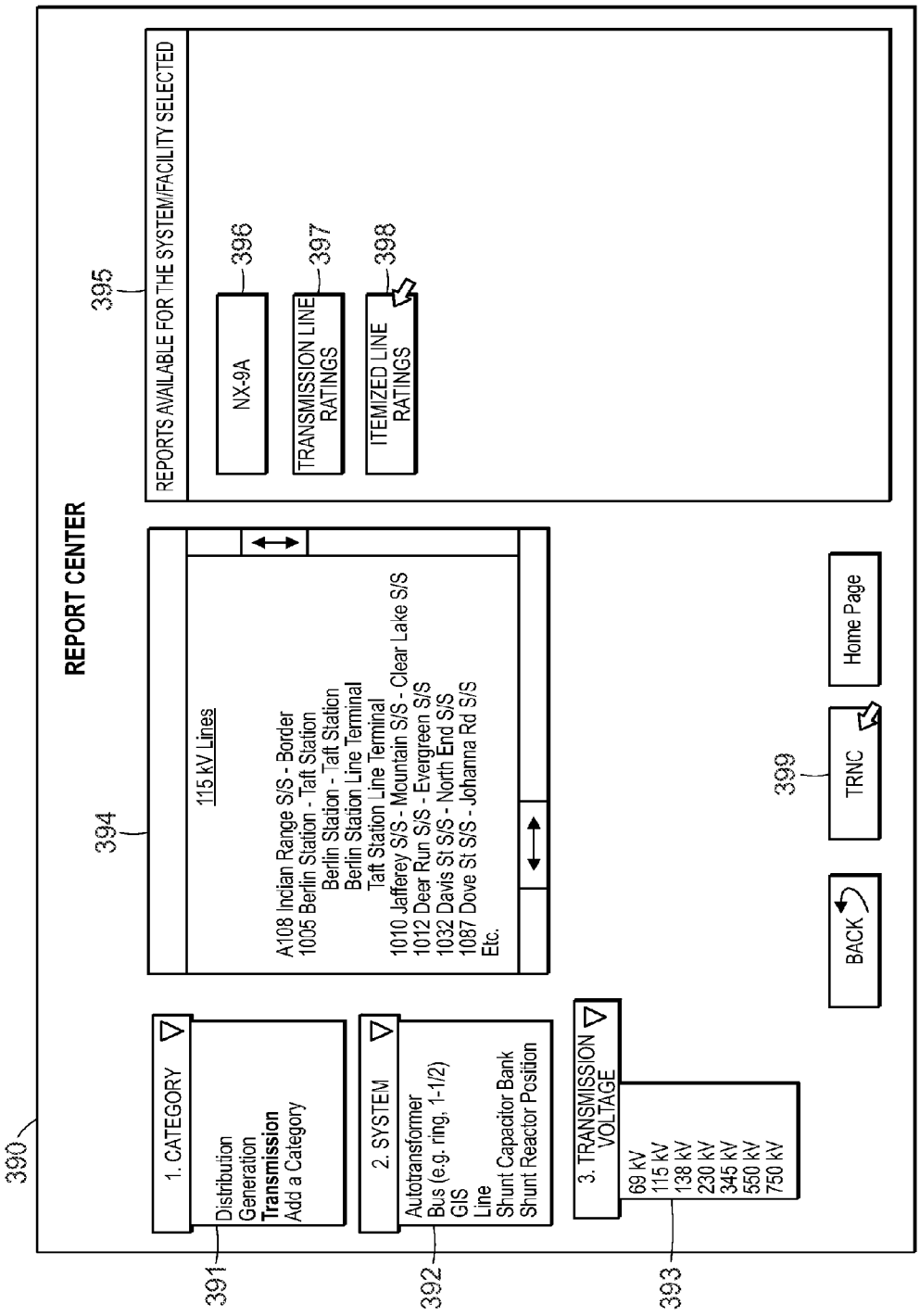
390
REPORT CENTER
395
REPORTS AVAILABLE FOR THE SYSTEM/FACILITY SELECTED
396
NX-9A
397
TRANSMISSION LINE RATINGS
398
ITEMIZED LINE RATINGS
394
115 kV Lines
A108 Indian Range S/S - Border
1005 Berlin Station - Taft Station
Berlin Station - Taft Station
Berlin Station Line Terminal
Taft Station Line Terminal
1010 Jafferey S/S - Mountain S/S - Clear Lake S/S
1012 Dear Run S/S - Evergreen S/S
1032 Davis St S/S - North End S/S
1087 Dove St S/S - Johanna Rd S/S
Etc.
399
TRNC
Home Page
BACK
1. CATEGORY
Distribution
Generation
Transmission
Add a Category
2. SYSTEM
Autotransformer
Bus (e.g. ring, 1-1/2)
GIS
Line
Shunt Capacitor Bank
Shunt Reactor Position
3. TRANSMISSION VOLTAGE
69 kV
115 kV
138 kV
230 kV
345 kV
550 kV
750 kV
391
392
393

FIG. 16

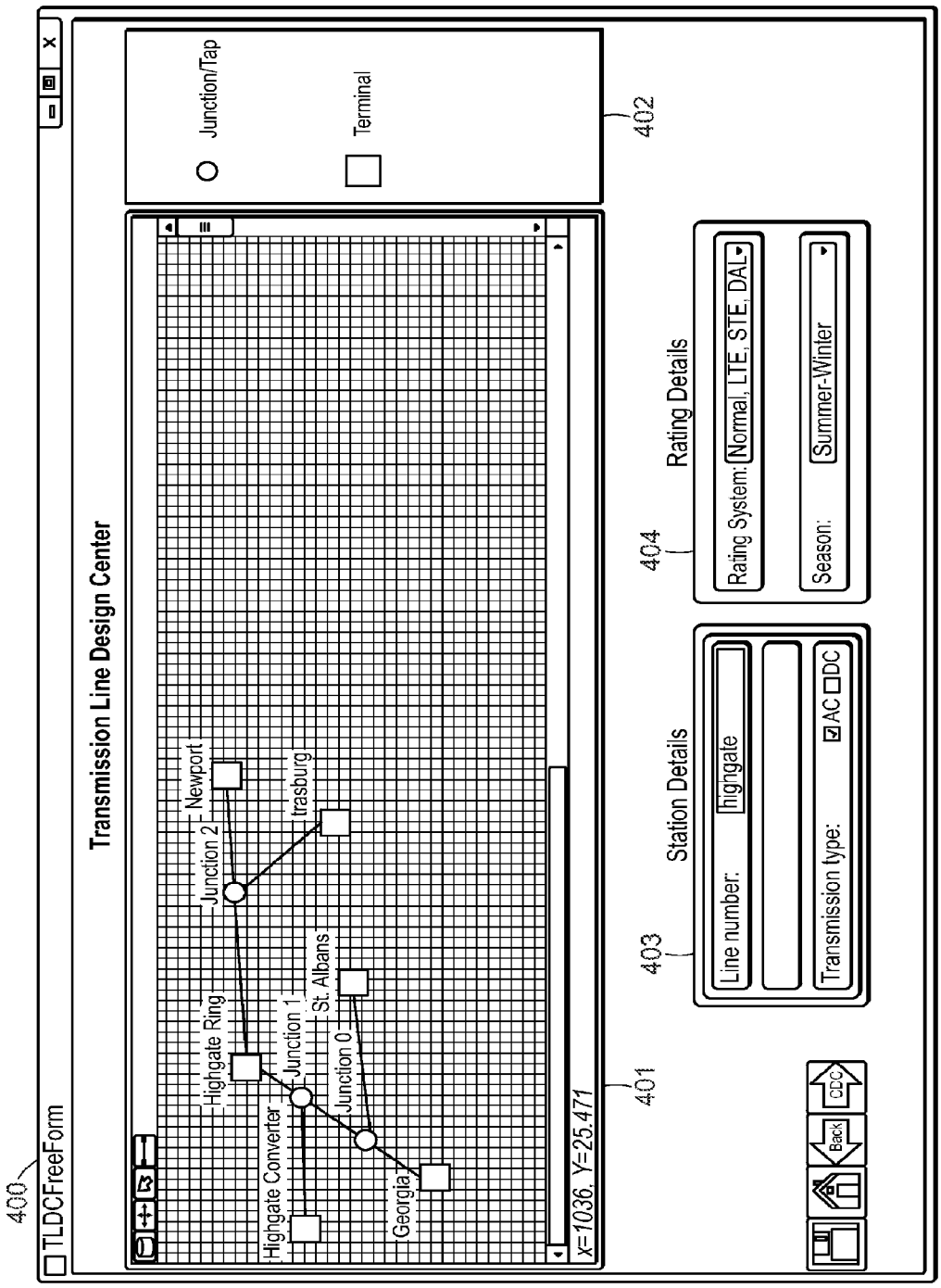
400
TLDCFreeForm
Transmission Line Design Center
Junction/Tap
Terminal
402
Newport
Junction 2
trasburg
Highgate Ring
Junction 1
St. Albans
Highgate Converter
Junction 0
Georgia
x=1036, Y=25.471
401
Rating Details
404
Rating System: Normal, LTE, STE, DAL
Season: Summer-Winter
Station Details
403
Line number: highgate
Transmission type: AC DC
Back
CDC

FIG. 17

ELECTRICAL TRANSFER CAPACITY OPTIMIZATION SYSTEMS AND METHODS THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation-In-Part of U.S. non provisional application Ser. No. 13/073,333 filed Mar. 28, 2011. All recited applications are incorporated herein by reference in their entirety and priority is date is claimed under those applications.

FIELD OF THE INVENTION

The invention relates generally to a system and method of computing and optimizing electric loading transfer capabilities, and more specifically, to a computer system capable of generating real-time electric transfer capacity ratings for one or more electric power facilities.

BACKGROUND OF THE INVENTION

With the electric industry's transition from a traditional rate-based regulation towards a deregulated energy marketplace, electricity consumers now have the ability to select their electricity services from various energy suppliers. Under the deregulated scheme, the transmission of bulk electric power continues to be regulated—by the Federal Energy Regulatory Commission (FERC), the North American Electric Reliability Corporation (NERC), and Regional Transmission Operators (RTO)—and remains the responsibility of local utility companies. This restructuring of the energy marketplace allows for consumers to have their electricity produced, transported and delivered from more than one provider. By supplying consumers with increased options for procuring their electricity needs, energy deregulation aims to improve reliability of the electric power system, serve increasing electricity demands, foster market competition, and thus lower the price of electricity.

The competition has affected how energy suppliers generate, transmit, and distribute electric power. For example, bulk power exchange between different electric-utility service areas has become more common today. There is an increased need to buy and sell electric power over longer distances. This transfer of power has placed greater demand and strain on existing generation and transmission facilities. As a result, many power grid regions have experienced power outages and curtailments. Potential causes for the power outages include unexpected energy demand spikes, unreliable electric power systems, and overtaxed electric transmission lines and substation components.

In order to meet the everyday demands for electricity and for the facilities used the transfer of bulk electric power are reliable and secure, the FERC, NERC and RTO's have developed reliability standards and rules for market participants that focus on energy planning, and facility design, management and operation. Moreover, energy planning and management helps with the increasingly complicated energy transactions, involving generation of bulk electric power from multiple suppliers, swapping electric power on the national grid, and sharing of regional transmission lines.

Consequently, it is desirable to introduce a method and system that can address the prior art's shortcomings while providing optimized energy transmission through asset planning and management during operations. It would also be desirable to have such a system that can accurately simulate

and dynamically compute the electric transfer capacity ratings (also known as facility ratings, thermal ratings, or load capability), accounting for a plurality of variable factors including ambient weather conditions and material construction characteristics of components used in facilities that comprise electric power distribution, generation and transmission systems.

SUMMARY OF THE INVENTION

Accordingly, the shortcomings of the prior art are overcome and additional advantages are provided through the provision of a method and related system for optimizing electric loading transfer capabilities. In one embodiment, the system comprises a processor which receives and stores information regarding resources of one or more electric power facilities. The system also includes a capability datastore and an external factors datastore, both of which communicate with the processor and with each other. The capability datastore determines electrical transfer capabilities of the resources as a function of time duration and at any given point in time. The external factors datastore determines a plurality of variables which affect the electrical transfer capabilities. The system further comprises a resource manager, which is in processing communication with the processor, the capability datastore, and the external factors datastore. The resource manager allocates the plurality of resources by optimizing the electrical transfer capabilities as a function of time duration and at a given point in time and by correlating the plurality of variables with the electrical transfer capabilities in order to generate electric capacity ratings for one or more electric power facilities as a function of time duration and at any given point in time.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of practice, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings in which:

FIG. **1** is a block diagram illustrating the overall system structure as per one embodiment of the present invention, showing connectivity among the system modules;

FIG. **2** is an illustration of a networked environment as per embodiment of FIG. **1**;

FIG. **3** is another illustration of a networked environment showing processing communication with an external memory and other external sources as per embodiment of FIG. **1**;

FIG. **4** is a flow chart illustration as per embodiment of FIG. **1** showing the design of a virtual model of one or more electric power facilities;

FIG. **5** is a flow chart illustration as per embodiment of FIG. **1** showing the calculation of an electric capacity rating of the one or more electric power facilities;

FIG. **6** is an exemplary view of an initial startup window of a graphical user interface as per one embodiment of the present invention;

FIG. **7** is an exemplary view of the graphical user interface such as provided by embodiment of FIG. **6** illustrating a thermal rating navigation window for allowing a user to create, modify, display, or print information relating to energy needs;

FIG. **8** is an exemplary view of the graphical user interface such as provided by embodiment of FIG. **6** showing a power facility design window for building and configuring a transmission station present in one or more electric power facilities;

FIG. **9** is an exemplary view of the graphical user interface such as provided by embodiment of FIG. **6** having a component design window showing resources or electrical equipment that can be used to assemble a virtual model of one or more electric power facilities;

FIG. **10** is an exemplary view of a graphical user interface such as provided by embodiment of FIG. **6** showing an equipment library window for specifying properties of a resource, such as an electrical bus;

FIG. **11** is an exemplary view of a graphical user interface such as provided by embodiment of FIG. **6** having a rating parameters window wherein a plurality of variables can be defined;

FIG. **12** is an exemplary view of a graphical user interface such as provided by embodiment of FIG. **6** having a conductor rating conditions window wherein a plurality of variables regarding conductor conditions and construction characteristics can be defined;

FIG. **13** is an exemplary view of a graphical user interface such as provided by embodiment of FIG. **6** showing an equipment library window for specifying properties of a resource, such as a manual disconnect;

FIG. **14** is an exemplary view of a graphical user interface such as provided by embodiment of FIG. **6** having a thermal ratings window showing an itemized list of electric transfer capacity ratings as a function of time duration for each individual resource present in one or more electric power facilities;

FIG. **15** is an exemplary view of a graphical user interface such as provided by embodiment of FIG. **6** having an ambient ratings window showing comprehensive electric transfer capacity rating of one or more electric power facilities with a defined plurality of variables; and

FIG. **16** is an exemplary view of a graphical user interface such as provided by embodiment of FIG. **6** having a report center window used for generating a report about electric capacity ratings of the one or more electric power facilities.

FIG. **17** is an exemplary view of a graphical user interface such as provided by embodiment of FIG. **6** having a transmission line design center window used for building a virtual model of transmission lines between electric transmission stations and electric shared stations.

DETAILED DESCRIPTION OF THE INVENTION

FIGS. **1-16** provide an electric transfer capacity rating model, wherein the model reflects the relationships between electrical transfer capabilities of resources present in one or more electric power facilities and external factors, such as weather parameters, and material and construction characteristics of components used in electric power facilities which affect the electrical transfer capabilities as a function of time duration. The model can be repeatedly updated and used to calculate the electric capacity rating as a function of time duration of the one or more electric power facilities. In order to effect repeated calculations, a plurality of variables representing the external factors are continuously measured or sampled and the electrical transfer capabilities as a function of time duration are automatically updated. Thereafter, the model is evaluated with the above updated or tuned parameters. The model may be updated without excessive computational efforts as frequently as desired, resulting in electric capacity ratings of the one or more electric power facilities.

While described below in a single computer environment, the system and method for calculating electric transfer capacity ratings of one or more electric power facilities can be implemented in a networked computing arrangement in which a number of computing devices communicate over a local area network (LAN) or over a wide area network (WAN). Such an environment can include large scale wireless communications between a host computer and several portable computer terminals, including weather monitoring equipment and global positioning system units located on-site where the physical resources or electrical equipment of the one or more electric power facilities are positioned.

FIG. **1** is a block diagram illustrating one embodiment of the present invention. An electric capacity rating system **100** includes at least one processor **101** and a plurality of modules **102**, **103**, **104**, **105**, **106**, all in processing communication with one another. The processor **101** serves to receive and store information regarding the resources present in one or more electric power facilities. The resources contained within an electric power facility include overhead line conductors as well as other electric generation, distribution, and transmission components. Note, in one embodiment of the present invention, the modules **102**, **103**, **104**, **105**, **106** are part of the processor **101** and thus constitute units established internally within the processor **101**. As will be appreciated by those skilled in the art, in an alternate embodiment, any of the modules **102**, **103**, **104**, **105**, **106** may form individual units established separate from the processor **101**.

In one embodiment, a capability datastore is provided as shown and referenced by numeral **102**. The capability datastore **102** determines the electrical transfer capabilities of each individual resource at any given point in time. Generally, the electrical transfer capabilities comprise one or more electric transmission, distribution, or generation transfer capabilities. More specifically, the electrical transfer capabilities of a resource represent the capacity of the resource to transfer electric power as a function of time duration and at any given point in. The capacity is often defined as the maximum allowable current, or the highest ampacity, at which the resource can be operated for a given time duration without violating safety codes or the integrity of the resource.

An external factors datastore is also provided as shown and referenced by numeral **103**. The external factors datastore **103** maintains a collection of variables, which affect the electrical transfer capabilities of each resource as a function of time, and communicates the collection of variables to the processor **101** at any given point in time in order to update the electrical transfer capabilities. Furthermore, a resource manager, shown and referenced as numeral **104**, connects to the processor **101** to perform a majority of the processing functions of the electric capacity rating system **100**. Specifically, the resource manager **104** allocates the plurality of resources by optimizing the defined electrical transfer capabilities. In turn, the resource manager **104** correlates the plurality of variables with the electrical transfer capabilities in order to generate an electric capacity rating as a function of time duration for one or more electric power facilities being analyzed.

In one embodiment, a clock, as shown and referenced by numeral **106**, is coupled to processor **101** and provides a clock signal for electric transfer capacity rating system **100**. Clock **106**, in turn, provides time and date information to the

processor **101** as well as the capability datastore **102**, the external factors datastore **103**, and the resource manager **104**. In one embodiment, system **100** reads an internal clock from a host computer **150** and updates the clock **106**. In another embodiment, a network clock **151** is used to update clock **106**. As will be appreciated by those skilled in the art, the use of a clock can be substituted or omitted in alternate embodiments.

The system **100** also has a memory unit, as shown and referenced by numeral **105** in FIG. **1**, wherein the processor **101** can read and write compiled data. The memory unit **105** can be contained within the processor **101**, as shown in FIG. **2**. As such, the memory unit **105** is internal memory integrated with the processor **101**. Alternatively, the memory unit **105** can be external memory, which can be remotely accessible by the processor **101**.

FIG. **3** illustrates one embodiment of the present invention having an external memory unit **105** embedded in a large computer such as a server. The connection between the processor **101** and the memory unit **105**, regardless if internal or external, comprises at least one data port interface **109**. The data port interface **109** provides the means for supporting a plurality of independent communication channels **110** (as shown in FIG. **1**), which act in cooperation with each other and with the processor **101** and memory unit **105**.

The compiled data that is saved in the memory unit **105** includes information about: (i) the plurality of resources; (ii) the electrical transfer capabilities determined by the capability datastore **102**; and (iii) the plurality of variables ascertained by the external factors datastore **103**. In addition to providing storage for the compiled data, the memory unit **105** offers various tiers of information technology security. This plurality of security levels accommodates the different standards of conduct to be observed between regulated and unregulated groups (i.e. transmission providers and all their energy affiliates, independent system operators, regional transmission organizations) within the one or more electric power facilities. An example of a standard of conduct can be the Standards of Conduct and Audits defined by the Federal Energy Regulatory Commission. However, the memory unit **105** maintains the flexibility to provide different levels of security to meet any standards of conduct enforced by any agency, commission, or party.

FIG. **4** is a flow chart illustrating the electric transfer capacity rating system **100** of an embodiment of the present invention as it initiates the process of optimizing the electric loading transfer capabilities as a function of time duration of the one or more electric power facilities. Specifically, the system **100** provides the means to design a virtual model of the one or more electric power facilities to be analyzed. In step **201**, the processor **101** allows a system user to create a record in which to build the virtual model of said one or more electric power facilities. The processor **101**, in step **202**, provides a means to construct the virtual model by assembling symbols which represent the plurality of resources present in the electric power facilities. The plurality of resources can include any combination of electric generation, distribution and transmission components, as well as the components material and construction characteristics. Some examples of electric generation, distribution, and transmission components are overhead line conductors, underground cables, conductor splices, conductor compression terminals, buses, disconnects, wave traps, current limiting reactors, circuit breakers, circuit switches, current transformers, series capacitors, shunt capacitors, substations, and relays. In step **203**, the processor **101** accesses equipment libraries in order to retrieve the resource symbols needed to create the virtual model.

Once the virtual model has been constructed, the system **100** proceeds with step **204**, wherein the capability datastore **102** provides information on the electrical transfer capabilities of each of the plurality of resources present in the one or more electric power facilities. The information pertaining to electrical capabilities can include resource equipment properties, resource composition, resource construction, and resource thermal limits. Other information not mentioned above can also be selectively provided as will be appreciated by those skilled in the art.

In step **205**, the processor **101** receives the electrical transfer capabilities from the capability datastore **102**, and directs the resource manager **104** to develop and associate a mathematical rubric, including one or more formulas or algorithms, with each of the plurality of resources. If the mathematical rubrics do not require input of a plurality of variables, the resource manager proceeds to step **207**. However, if the mathematical rubrics require quantities for a plurality of variables, the processor **101** in step **206** requests such information from the external factors datastore **103**. The plurality of variables provided by the external factors datastore **103** includes important weather parameters, such as ambient temperature, wind speed, and wind direction. Other weather parameters, such clarity of atmosphere, solar radiation, air density, air viscosity, and air thermal conductivity, may also be included. The plurality of variables also comprise non-weather-related parameters, such as geographic position and elevation above sea level of said one or more electric power facilities, orientation of said plurality of resources, time of day, day of year, seasonal period, as well as the properties, physical dimensions and types of materials used in the construction of plurality of variables.

Before the external factors datastore **103** sends the plurality of variables to processor **101**, the plurality of variables are updated either dynamically by external sources **120** or manually by user input. Specifically, with respect to updating weather parameters, the external sources **120** may comprise a meteorological institute. Supervisory Command and Data Acquisition (SCADA) systems **121** and other remote access systems may also provide the necessary data to update the plurality of variables. Alternatively, weather measurement sensors placed near the locations of the resources can also serve as the external sources **120**. Furthermore, if dynamic updates from external sources **120** or manual updates are not available, the external factors datastore **103** can define the plurality of variables using old values previously saved in the memory unit **105**.

Continuing in step **206**, the resource manager **104** applies the plurality of variables to the mathematical rubrics. After the mathematical rubrics have been populated with the plurality of variables, the resource manager **104** proceeds with step **207**, wherein the manager **104** links together the mathematical rubrics of the plurality of resources. As a result of the linking, the manager **104** forms a comprehensive representation, which characterizes the one or more electric power facilities as a single, homogenous system. In step **208**, the processor **101** saves the record of the one or more electric power facilities, including the comprehensive representation and compiled data, to the memory unit **105**. This record can later be retrieved for future observation, modification, or analysis of electric capacity rating of the one or more electric power facilities.

FIG. **5** is a flow chart illustrating the electric transfer capacity rating system **100** of an embodiment of the present invention as it computes the electric transfer capacity rating

as a function of time duration of the one or more electric power facilities. In step **220**, the processor **101** retrieves the record of the one or more electric power facilities, including the comprehensive representation, from the memory unit **105**. Subsequently, in steps **221** and **223**, the capability datastore **102** updates the electrical transfer capabilities, and the external factors datastore **103** updates the plurality of variables, respectively. Since weather conditions can change within short periods of time and have a significant effect on electric transfer capacity ratings, it is particularly important that weather parameters are updated. The updated plurality of variables and electrical transfer capabilities are then saved to the memory unit **105** in steps **222** and **224**. In order to reflect the current conditions of the one or more electric power facilities, the processor **101** in step **225** directs the resource manger **104** to implement the updated plurality of variables and electrical transfer capabilities into the comprehensive representation. Afterwards, the resource manager **104** uses the comprehensive representation to calculate the electric transfer capacity ratings as a function of time duration of the one or more electric power facilities, as shown in step **226**.

In steps **227-229**, the processor **101** displays the electric transfer capacity ratings and compiled data (i.e. plurality of resources, electrical capabilities, and plurality of variables) in a graphical user interface **107**, generates a report documenting the above information, and saves the above information into the memory unit **105**. Finally, in step **230**, the resource manager **104** performs optimization of the electric transfer capacity rating. For instance, the resource manager **104** achieves a higher transfer capacity rating by optimizing the electrical transfer capabilities with the plurality of resources given updated plurality of variables. In turn, the electric transfer capacity rating can be used temporarily by operators of the one or more electric power facilities to distribute or transmit more electricity for a given time duration more effectively and efficiently. As shown in step **231**, the processor **101** sends the electric transfer capacity ratings through at least one peripheral link **122** to a network of Supervisory Command and Data Acquisition (SCADA) systems **121** (as shown in FIGS. **1-3**). This allows the processor **101** to interpret and manipulate real-time alarms of the SCADA systems **121**, thus reducing the need for drastic actions, such as shedding electric loads or transferring electric loads from one electric power facility to another.

FIGS. **6-16** provide different views of the graphical user interface (GUI) **107** of the electric transfer capacity rating system **100**. FIG. **6** is an exemplary view of an initial startup window **301** of the GUI **107** for enabling a user to easily navigate through and perform a desired task in the system **100**. The initial startup window **300** displays icons representing various application windows of the system **100**. For example, the user may select icon **301** to gain access to the thermal rating navigation window where the user can begin the process of optimizing the electric loading transfer capabilities of the one or more electric power facilities, as designated in steps **201-208**, **220-231**. When icon **302** is selected, the user is directed to the report center window where the user can view, generate, and disseminate reports regarding analysis of electric transfer capacity ratings previously conducted. The user may select icon **303** to gain access to the equipment library window, which allows the user to view symbols representing resources that can be used to assemble a virtual model of the one or more electric power facilities.

As shown in FIG. **7**, the GUI **107** displays a thermal rating navigation window **304** after the user has selected icon **301** from the initial startup window **300**. The thermal rating navigation window **304** maintains various panels and buttons in which the user may manipulate to design or edit a virtual model of the one or more electric power facilities, to view or optimize the electric loading transfer capabilities of the one or more electric power facilities, or to generate a report of the electric loading transfer capabilities as a function of time of the one or more electric power facilities.

Category panel **305** is a listing of options representing various types of electric power facilities. The category panel **305** typically shows a "Distribution" option representing an electric power distribution facility, a "Generation" option representing an electric power generation facility, and a "Transmission" option representing an electric power transmission facility. In addition, an option labeled "Add a Category" is included in the listing of options to allow the user to load and select other categories of an electric power facility.

Once the user selects an option in category panel **305**, system panel **306** displays a list of electric power facilities identified under the chosen category. In this example, the user selected the "Transmission" option in category panel **305**. As a result, the system panel **306** shows different systems of electric power transmission facilities (i.e. "Transformer Positions", "Line", "Station Bus", "Shunt Capacitor Position", "Shunt Reactor Position"). In a similar manner, voltage panel **307** becomes populated with various voltage ratings once the user chooses a particular system of electric power facility in the system panel **306**. Each rating displayed in voltage panel **307** represents a voltage in which the selected electric power facility may be rated. In this example, the user selected the "Station Bus" electric power facility in system panel **306**, and as a result, voltage panel **307** displays multiple voltage ratings. Once the user selects a specific voltage rating, query panel **308** lists records saved in memory **105** which reflect the user-selected combination of category, system, and voltage rating. The user may then choose any one of the listed records of electric power facilities to view or edit.

The thermal rating navigation window **304** also provides several command buttons to initiate different actions by the electric capacity rating system **100**. After making selections in category panel **305**, system panel **306**, and voltage panel **307** and choosing a record in query panel **308**, the user may modify the virtual model (of the one or more electric power facilities) saved within that record by selecting the edit button **309**. Alternatively, if the user wants to construct a new virtual model (and thus new record), the user may select the create button **310**, as shown in FIG. **7**. Moreover, the user need only select the homepage button **311** to return to the initial startup window **300**.

Following the selection of the create button **310**, the GUI**107** displays a power facility design window **312**, as illustrated in FIG. **8**. More specifically, based on the selections the user made in the thermal rating navigation window **304**, the power facility design window **312** will display various panels which will enable the user to begin the design process reflected in steps **201**, **202**, **203**. In this example, the user chose to create a 345 kV transmission station bus. As a result, several configuration panels are provided for the user to manipulate to define specific features of the transmission station bus. In a current type panel **313**, the user is able to choose whether the flow of electricity is alternating current (AC) or direct current (DC). A class panel **314** allows the user to specify the type of transmission station bus is being

created. In this example, because the user selected "1½ breakers" as the bus type, a bays panel **315** is provided for the user to identify the number of 1½ breaker bays present in the transmission station bus. In station name panel **316** and scheme name panel **317**, the user can enter names with which to identify the current record of the one or more electric power facilities being created. A rating system panel **318** and a seasonal rating panel **319** allow the user to indicate a precise rating arrangement for the transmission station bus. The power facility design window **312** also shows a tabular display **320** and graphical image **321** representative of the one or more electric power facilities according to the user's specifications. For example, since the user specified three breaker bays for the transmissions station bus, the tabular display **320** shows three entries for each bay while the graphical image **321** shows a line representation of a transmission station bus having a "Bus A" and a "Bus B" connected via three breaker bays.

Command buttons are also provided in the power facility design window **312** to allow the user to navigate to other application windows or to perform designated functions. In particular, a save record button **322** is provided for the user to save the record of the one or more electric power facilities being created. The user may also select a component design button **323** which also saves the record and subsequently directs the user to a component design window **324**, as illustrated in FIG. **9**.

In the component design window **324**, the user can build in detail an exact combination and sequence of resources present in the one or more electric power facilities. The component design window **324** comprises of three main panels: a graphical display panel **325**, a workspace panel **326**, and an equipment library panel **327**. Within the graphical display panel **325**, the user can see a line representation of the one or more electric power facilities. Moreover, the user can highlight a specific portion of the line representation to begin the design process. To start designing the one or more electric power facilities, the user first refers to the equipment library panel **327**, where various symbols representing electric power facility resources (i.e. equipment) are listed. Once the user finds a resource to be utilized in the building of the highlighted portion of the electric power facility, the user selects the symbol and drag-and-drops the symbol inside the workspace panel **326**. The user executes the same maneuver for the other resources to be utilized in building the highlighted portion of the electric power facility. Within the workspace panel **326**, the user can then connect the resource symbols in any particular sequence.

Furthermore, within the workspace panel **326**, the user can double-click on any one of the symbols to view and modify the properties of that resource. In this example, the user double-clicks on symbol **328**A labeled "Circular Rigid Bus." As a result, an equipment library window **329**, as shown in FIG. **10**, displays on the GUI **107**. The equipment library window **329** provides various command buttons and panels for the user to manipulate in order to specify properties and materials of the selected resource. In this example, when the user selected a command button **330** labeled "Rigid Circular Bus," a properties panel **331** appears. Within the properties panel **331**, the user can identify the specifications of the rigid bus to be used by selecting any one of the choices that are.

Once a selection has been made, the user must apply additional parameters for the resource (i.e. rigid circular bus) by selecting an apply parameters button **332**. In selecting the apply parameters button **332**, the user navigates to a rating parameters window **333**, as illustrated in FIG. **11**. The rating parameters window **333** allows the user to establish the geophysical location of the resource and climate parameters associated with the resource. Using location panels **334**, **335**, **336**, **337**, the user can indicate the country, state, city, and latitude in which the resource is located. Alternatively, the user may choose from a location panel **338** a location record previously saved. By choosing a location record, such as "Anniston Central" in this example, the location panels **334**, **335**, **336**, **337** become automatically set.

The rating parameters window **333** provides date-time panels to specify the time period in which electric transfer capacity ratings are to be calculated. In this example, since a "winter-summer" seasonal rating was selected in the seasonal rating panel **319** of the power facility design window **312** (FIG. **8**), the rating parameters window **333** shows four date-time panels **339**, **340**, **341**, **342** to configure the dates and times when a summer rating and a winter rating are to be determined, and also to define the time durations for individual rating periods within the summer and winter seasons. Furthermore, an orientation panel **343**, atmosphere panel **344**, and elevation panel **345** allow the user to specify the orientation of the resource, the clarity of the atmosphere, and the elevation above sea level of the resource, respectively.

After the user has specified the geophysical and climate rating parameters, the user can select an apply gpc button **346** which will apply these parameters to the resource and subsequently direct the user to a conductor rating conditions window **348**, as shown in FIG. **12**. If, however, the user prefers not to apply the geophysical and climate rating parameters, the user can select the next screen button **347** to navigate directly to the conduct rating conditions window **348**.

In the conduct rating conditions window **348** of the GUI **107**, the user can specify more detailed parameters for the selected resource (i.e. circular rigid bus). Depending on the selections made in the rating system panel **318** and the seasonal rating panel **319** of the power facility design window **312** (FIG. **8**), a distinct set of atmospheric panels and emergency parameter panels will appear in the conduct rating conditions window **348**. In this example, the user is given atmospheric panels **349**-**356** to indicate various atmospheric factors. In atmospheric panel **349**, the user can input an ambient air temperature for the summer season. In atmospheric panel **350**, the user can input a wind speed for the summer season. The user can also input an ambient air temperature and wind speed for the winter season in atmospheric panels **351**, **352** respectively. In atmospheric panels **353**, **354**, **355**, **356**, the user can specify an angle between wind direction and the resource for each the summer and winter seasons, a coefficient of emissivity, and a coefficient of solar absorptivity. Furthermore, emergency parameter panels **357**-**364** are provided for the user to configure, for both winter and summer seasons, a short-term emergency time duration, a preload level for short-term emergency, a drastic action limit time duration, and a preload level for the drastic action limit. In resource temperature panels **365**, **366**, the user can either select a default value or input an express value for normal resource temperature and maximum resource temperature. To apply these parameters, the user must then select an apply ere button **367**. Command buttons **368** are also provided to give the user the ability to quickly navigate to other application windows, such as the component design window **324** or the equipment library window **329**.

FIG. **13** is another exemplary view of an equipment library window **370** after the user double-clicks on a symbol

328B labeled "Manual Disconnect" in the component design window **324** (FIG. **9**). The equipment library window **370** provides various command buttons and panels for the user to manipulate in order to specify properties and materials of the selected resource.

Finally, after all parameters for a particular resource have been set and applied, the user can begin the process of calculating the electric transfer capacity rating as a function of time duration of the one or more electric power facilities by selecting a run thermal ratings button **369** in the conductor rating conditions window **348** (FIG. **12**). When the user makes this selection, he is directed to a thermal ratings window **371**, as illustrated in FIG. **14**. A facility analysis panel **372** shows the one or more electric power facilities being analyzed for its electric transfer capacity ratings. In this example, the electric transfer capacity ratings of a transmission line between two transmission stations is being calculated and optimized. Also, a facility summary panel **373** shows top-level information regarding the one or more electric power facilities being analyzed, such as operating voltage, length of the transmission line, and line constants.

A calculate command button **377** allows the user to initiate the process of calculating the electric transfer capacity ratings as a function of time for each resource present in the one or more electric power facilities. As a result, a resource thermal rating panel **374** itemizes summer and winter electric transfer capacity ratings for each resource based on different rating time durations (i.e. normal, long-term emergency, short-term emergency, drastic action limit). A status view panel **375** gives the user the ability to control which resources will appear in the resource thermal rating panel **374**. In this example, since the "In Service and To Be Installed Less To Be Removed" option is selected in the status view panel **375**, the resource thermal rating panel **374** displays all the resources present in the one or more electric power facilities. Other options in the status view panel **375** adjust the resource thermal rating panel **374** to hide the information concerning resources that are out of service or that are scheduled to be removed.

A summary thermal rating panel **376** is also included in the thermal ratings window **371**. The summary thermal rating panel **376** compares the electric transfer capacity ratings of all the resources displayed in the thermal rating panel **374** and displays the minimum values for each rating time duration (i.e. Normal, LTE, STE, DAL). These minimum values in turn reflect the overall electric transfer capacity ratings of the one or more electric power facilities. Additionally, the user can adjust the units, such as amperes to apparent power (MVA), in which the electric transfer capacity ratings are calculated and displayed.

FIG. **15** is an exemplary view of an ambient ratings window **379** of the GUI **107**. To reach this application window, the user can select an ambient ratings button **378** in the thermal ratings window **371** (FIG. **14**). In the ambient ratings window **379**, the user is able to update various weather parameters and recalculate electric transfer capacity ratings according to these adjusted weather parameters. In this particular example, the ambient ratings window **379** provides a time-of-day panel **380** and day-of-year panel **381** for the user to specify values for the time of the day and the day of the year. In addition, the user can adjust the wind speed, air temperature, and clarity of atmosphere through a wind speed panel **382**, air temperature panel **383**, and atmospheric clarity panel **384**, respectively. As an alternative to updating the time and weather parameters individually, the user can load a record of previously saved time and weather parameters via an ambient records panel **385**. Once updated time and weather parameters are specified, the user must select a run button **386** to re-compute electric transfer capacity rating values as a function of time duration. The new electric transfer capacity rating values will then appear in a summary ambient ratings panel **387**. After the new values have been computed, the user can save them into a record by selecting the save record button **388**. Moreover, the user can begin the process of generating a report of the electric transfer capacity ratings by selecting a report button **389**.

A report center window **390**, as illustrated in FIG. **16**, appears on the GUI **107** when the user selects the report button **389** in the ambient ratings window **379**, or any report button displayed in any of the previously discussed windows. In the report center window **390**, the user can choose to generate a report of the electric transfer capacity ratings for any of the one or more electric power facilities saved in a record in the memory unit **105**. To choose a specific electric power facility, the user must select the category of electric power facility (i.e. distribution, generation, transmission) from a category panel **391**. A system panel **392** subsequently displays a list of electric power facilities identified under the chosen category. After the user makes a selection in the system panel **392**, a voltage panel **393** displays various voltage ratings in which the selected electric power facility may be rated. In this example, the user selected the "Transmission" option in the category panel **391**, the "Line" option in the system panel **392**, and the "115 kV" option the voltage panel **393**. A query panel **394** then lists all available electric power facilities which meet the chosen criteria (i.e. user's selections).

From the query panel **394**, the user selects the specific electric power facility for which he or she would like to generate a report. In addition, a report selection panel **395** gives the user the ability to choose the type of report to generate. In this example, the user can choose to generate a NX-9A document (i.e. facility rating and characteristics data implementation form), an overall electric transfer capacity ratings report, or an itemized electric transfer capacity ratings report by selecting a NX-9A button **396**, line rating report button **397**, or itemized rating report button **398**, respectively. Once a report has been generated, the user can optimize the electric capacity ratings of other electric power facilities by selecting a trnc button **399** which navigates the user back to the thermal rating navigation window **304** (FIG. **7**).

It should be noted that any time or weather related parameters which the user manually inputs into the system **100** can be automated and obtained from external sources **120**. More specifically, the date-time panels **339**, **340**, **341**, **342** of the rating parameters window **333** (FIG. **11**), and the atmospheric panels **349-356** of the conduct rating conditions window **348** (FIG. **12**) can be automatically retrieved from a clock source or third-party meteorological data services. The time-of-day panel **380**, day-of-year panel **381**, wind speed panel **382**, air temperature panel **383**, and atmospheric clarity panel **384** of the ambient ratings window **379** (FIG. **15**) may also be updated in similar fashion.

FIG. **17** is an exemplary view of a transmission line design center window **400** of the GUI **107**. In this particular window, the user is able to design a virtual model of a network of transmission lines between electric transmission stations and electric shared stations (i.e. substations). The transmission line design center window **400** provides a library panel **402** where visual objects representing transmission lines (e.g. overhead conductors, underground cables), junctions (i.e. electrical node), and power stations

are listed. The user can select a visual object and drag-and-drop said visual object into a drafting panel **401**. Within the drafting panel **401**, the user can connect any sequence or combination of visual objects.

A station details panel **403** allows the user to specify the name and transmission type of each transmission line. Moreover, a rating details panel **404** lets the user designate the rating method and seasonal rating for the transmission lines. When a combination of visual objects representing a transmission line is saved, a mathematical rubric characterizes the combination and categorizes the combination into segments. The number of segments present in the combination depends on the quantity and orientation of stations and junctions used to create the transmission line. Each segment can then be selected in the component design window **324** and further defined by creating an electric circuit representation, using the symbols in equipment library panel **327**. Furthermore, each segment can have its own electric transfer capacity rating calculated. These electric capacity ratings can subsequently be reported to regional transmission operators and sent to their energy management systems for efficient management of regional electric transmission grids.

Although the invention has been described with reference to particular arrangement of parts, features, and the like, these are not intended to exhaust all possible arrangements or features, and indeed many modifications and variations will be ascertainable to those of skill in the art.

Reference throughout the specification to "one embodiment", "another embodiment", "an embodiment", and so forth, means that a particular element (e.g. feature, structure, and/or characteristic) described in connection with the embodiment is included in at least one embodiment described herein, and may or may not be present in other embodiments. In addition, it is to be understood that the described elements may be considered in any suitable manner in the various embodiments.

The terms "a" or "an", as used herein, are defined as one or more than one. The term "plurality", as used herein, is defined as two or more than two. The term "another", as used herein, is defined as at least a second or more. The terms "including" and/or "having", as used herein, are defined as comprising (i.e., open language). The term "coupled", as used herein, is defined as connected, although not necessarily directly, and not necessarily mechanically. The terms "optional" or "optionally" are defined such that the subsequently described event or circumstance may or may not occur, and that the description includes instances where the event occurs and instances where it does not.

The term "electric transfer capacity rating" or "transfer capacity", as used herein are defined as the quantity of electrical power or electric current for a given time duration an electrical component(s) or electric power facility(s) comprised of electrical components can allow to transfer (i.e. pass) through the component(s) or facility without compromising the integrity of the electrical component(s) of electric power facility.

The term electric power facility, as used herein is defined as system comprised of electrical components used in electric power distribution, generation and transmission. The terms function of time or function of time duration, as used herein are defined as for a given time period.

While the invention has been described in accordance with certain preferred embodiments thereof, those skilled in the art will understand the many modifications and enhancements which can be made thereto without departing from the true scope and spirit of the invention, which is limited only by the claims appended below.

What is claimed is:

1. An electric capacity rating system for determining the quantity of electrical energy that can flow through electric power facilities for a given time period and at any given point in time, comprising:

a processor for receiving and storing information about the capability of resources to transfer electric power in one or more electric power facilities;

a capability datastore in communication with said processor for determining electrical transfer capabilities of each resource in the one or more electric power facilities for a given time period and at any given point in time, wherein the resources include: overhead line conductors, underground cables, conductor splices, conductor compression terminals, buses, disconnects, wave traps, current limiting reactors, circuit breakers, circuit switches, current transformers, series capacitors, shunt capacitors, substations and relays;

an external factors datastore for determining a plurality of variables which affect said electrical transfer capabilities of electric power facilities; and

a resource manager for allocating said plurality of resources by optimizing said electrical transfer capabilities of electric power facilities for a given time period and at any given point in time based on said plurality of variables;

said resource manager correlating said plurality of variables with said electrical transfer capabilities of each resource to compute an overall electric transfer capacity rating for a given time period and at a given point in time for said one or more electric power facilities, wherein the overall electric transfer capacity rating indicates the quantity of electrical energy that can flow through said one or more electric power facilities; and

said resource manager, said external factors datastore, and said capability datastore being in processing communication with said processor and with each other.

2. The system according to claim **1**, wherein said processor commands a memory unit in order to read and write compiled data to said memory unit,

said compiled data comprises information about said plurality of resources, said electrical transfer capabilities of electric power facilities for a given time period and at any given point in time, and said plurality of variables;

said memory unit comprises an internal memory integrated with said processor.

3. The system according to claim **2**, wherein said memory unit further comprises an external memory accessible by said processor.

4. The system according to claim **2**, further comprising at least one data port interface supporting a plurality of independent communication channels in processing communication with each other and with said processor and said memory unit;

wherein said processor sends and receives said compiled data and said computed electric transfer capacity ratings, through said plurality of independent communication channels, to and from said memory unit, respectively.

5. The system according to claim **4**, wherein said plurality of resources comprises electric generation, distribution and transmission components, said plurality of variables comprises material and construction characteristics of electric generation, distribution and transmission components, said plurality of variables comprises weather parameters, said plurality of variables comprises geographic location on earth

where electric power facilities reside, and said electrical transfer capabilities comprises either generation, distribution or transmission transfer capabilities.

6. The system according to claim **5**, wherein said weather parameters include ambient temperatures, wind speed, wind direction, clarity of atmosphere, solar radiation, air density, air viscosity, and air thermal conductivity;

wherein said geographic location on earth include latitude and longitudinal coordinates and elevation above sea level;

wherein said material and construction characteristics of electric generation, distribution and transmission components include color of painted surfaces, type and dimensions of electrical insulating materials, type of metals, dimensions and configuration of said components;

wherein said electrical capabilities include resource equipment properties, resource composition, resource construction, and resource thermal limits of materials used to construct said plurality of components and resources; and

wherein said plurality of variables further comprises orientation of each of said plurality of resources, time of day, day of year, and seasonal period.

7. The system according to claim **6**, wherein said plurality of variables can be used to dynamically or manually compute electric transfer capacity by external sources by a system user;

said external factors datastore can define said plurality of variables using old values previously saved in said memory unit if dynamic updates from said external sources or manual updates are not available.

8. The system according to claim **7**, wherein said processor obtains said electrical capabilities from said capability datastore and directs said resource manager to associate each of said plurality of resources with a mathematical routine including one or more formulas or algorithms;

said mathematical routine reflecting said electrical transfer capabilities for a given time period of each of said plurality of resources; and

wherein said resource manager links together each of said mathematical routines and forms a comprehensive representation of said one or more electric power facilities as a homogenous system;

said processor saving a record of said comprehensive representation in said memory unit.

9. The system according to claim **8**, wherein said external factors datastore retrieves updated values of said plurality of variables from said external sources;

said processor directs said resource manager to use said updated values of said plurality of variables and said electrical transfer capabilities to define unknown quantities within said comprehensive representation;

said resource manager calculates a current value of said electric transfer capacity rating using said comprehensive representation; and

said processor saves said current value of said electric transfer capacity rating to said memory unit.

10. The system according to claim **9**, wherein said processor generates an analytical report documenting said compiled data and said electric transfer capacity rating, which are stored in said memory unit;

said processor communicating said analytical report to external entities.

11. The system according to claim **9**, further comprising a graphical user interface to assist in operating and automating said system;

said graphical user interface displaying said compiled data and said electric capacity rating, which are stored in said memory unit.

12. The system according to claim **9**, wherein said resource manager determines higher electric capacity ratings as for a given time period by optimizing said electrical transfer capabilities with said plurality of resources given said updated values of said plurality of variables, and said resource manager determines said higherelectric transfer capacity ratings for a given time period and at any given point in time according to set rules pertaining to safety limits and physical limits of said plurality of resources.

13. The system according to claim **12**, wherein said processor interprets and manipulates a plurality of Supervisory Command and Data Acquisition (SCADA) systems by communicating said electric transfer capacity ratings to said plurality of SCADA systems through at least one peripheral link.

14. A method for optimizing electric loading transfer capability, comprising:

establishing processing communication between a resource manager, an external factors datastore, a capability datastore, and a processor;

receiving and storing information about resources in one or more electric power facilities by said processor;

determining electrical transfer capabilities of each resource in the one or more electric power facilities for a given time period and at any given point in time using said capability datastore, wherein the resources include: overhead line conductors, underground cables, conductor splices, conductor compression terminals, buses, disconnects, wave traps, current limiting reactors, circuit breakers, circuit switches, current transformers, series capacitors, shunt capacitors, substations and relays;

determining a plurality of variables which affect said electrical transfer capabilities using said external factors datastore;

allocating said plurality of resources by using said resource manager to optimize said electrical transfer capabilities for a given time period and at any given point in time based on said plurality of variables;

correlating said plurality of variables with said electrical transfer capabilities of each resource to generate an overall electric transfer capacity rating for a given time period and at a given point in time of said one or more electric power facilities by using said resource manager, wherein the overall electric transfer capacity rating indicates the quantity of electrical energy that can flow through said one or more electrical power facilities.

15. The method according to claim **14**, farther comprising:

reading, writing, and storing compiled data to a memory unit by said processor; and

providing a plurality of security levels in said memory unit to accommodate different standards of conduct between regulated and unregulated groups involved with said one or more electric power facilities;

said compiled data comprises information about said plurality of resources, said electrical transfer capabilities, and said plurality of variables.

16. The method according to claim **15**, further comprising updating said plurality of variables dynamically by using external sources and manually by a system user; and

defining, said plurality of variables with old values previously saved in said memory unit, by using said

external factors datastore, if dynamic updates from said external sources or manual updates are not available.

17. The method according to claim **16**, further comprising:

retrieving said electrical transfer capabilities from said capability datastore by said processor; and

directing said resource manager to associate each of said plurality of resources with a mathematical routine including one or more formulas or algorithms, said mathematical routine reflecting said electrical transfer capabilities of each of said plurality of resources;

linking; together each of said mathematical routines using said resource manager;

forming a comprehensive representation of said one or more electric power facilities as a homogenous system; and

saving a record of said comprehensive representation in said memory unit by said processor.

18. The method according to claim **17**, further comprising:

retrieving updated values of said plurality of variables from said external sources by using said external factors datastore;

directing said resource manager by said processor to use said updated values of said plurality of variables and said electrical transfer capabilities to define unknown quantities within said comprehensive representation;

calculating a current value of said electric transfer capacity rating for a given time period by said resource manager using said comprehensive representation; and

saving said current value of said electric transfer capacity rating for a given time period to said memory unit by said processor.

19. The method according to claim **18**, further comprising determining higher electric capacity ratings for a given time period using said resource manager to optimize said electrical transfer capabilities with said plurality of resources given said updated values of said plurality of variables; and

determining said higher electric transfer capacity ratings according to set rules pertaining to safety limits and physical limits of said plurality of resources.

20. A computer program product comprising an optimized electric loading transfer tool including a non-transitory computer usable medium having computer readable program code means for causing a computer to effect method steps of:

establishing processing communication between a resource manager, an external factors datastore, a capability datastore, and a processor;

receiving and storing information about resources in one or more electric power facilities by said processor;

determining electrical transfer capabilities of each resource in the one or more electric power facilities for a given time period and at any given point in time using said capability datastore, wherein the resources include: overhead line conductors, underground cables, conductor splices, conductor compression terminals, buses, disconnects, wave traps, current limiting reactors, circuit breakers, circuit switches, current transformers, series capacitors, shunt capacitors, substations and relays;

determining a plurality of variables which affect said electrical transfer capabilities using said external factors datastore;

allocating said plurality of resources by using said resource manager to optimize said electrical transfer capabilities for a given time period and at any given point in time based on said plurality of variables;

correlating said plurality of variables with said electrical transfer capabilities of each resource to generate an overall electric transfer capacity rating for a given time period and at a given point in time of said one or more electric power facilities by using said resource manager: wherein the overall electric transfer capacity rating indicates the quantity of electrical energy that can flow through said one or more electric power facilities.

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